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# FURTHER OBSERVATIONS ON THE OSMOTIC PRESSURE OF THE JUICES OF THE POTATO PLANT[1]

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## INTRODUCTION

The observations made by the author[2] during the summer of 1918 have been continued during 1919, 1920, and 1922, and greenhouse readings were taken in 1921. The data obtained from juices produced during seasons of varying character and from a number of varieties of potato will extend the knowledge of one internal factor of annual plants, since no previous investigation seems to have covered such a lengthy period of time for one plant. Unfortunately, it was not possible to make any cryoscopic determinations during 1921, owing to other work; this was particularly regrettable, as 1921 was a very good year for the production of physiological tip burn of typical form.

As the literature on this subject was discussed in the report of the earlier work, it is unnecessary to refer to it here. It may be stated, however, that the work in 1918 was an attempt to ascertain whether the internal osmotic pressures of the juices from different parts of the potato plant varied in such a way as to be a possible factor in the production of tip burn. The readings seemed to show that although the juice of the growing leaves has a higher osmotic pressure during the early part of the season, the stems attain a still higher pressure as a result of the accumulation of sugars in the sap during the height of the activity of the plant, when the flowers and young tubers are being produced. It is just at this time that tip burn of the physiological type appears.

The writer is again indebted to Mr. R. L. Gale for the sugar determinations made in 1919 and for assistance in the cryoscopic determinations during that year. The methods used have already been described. The results obtained, while probably not absolutely accurate, as the material was not frozen before grinding and no pressure was used in extracting the juice, will give a fairly correct determination, as the same methods were used throughout and the readings obtained were made for comparison with each other only. These data are shown in Tables I, II, III, IV, and V.

[1] Accepted for publication Mar. 3, 1923.

[2] LUTMAN, B. F. OSMOTIC PRESSURES IN THE POTATO PLANT AT VARIOUS STAGES OF GROWTH. *In* Amer. Jour. Bot., v. 6, p. 181–202. 1919. Literature cited, p. 202.

TABLE I.—*Comparative cryoscopic readings in 1919*

| No. | Date. | Weather. | Material. | Depression. | Depression in atmospheres. | Glucose. | Sucrose. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| | | | | | | *P. ct.* | *P. ct.* | |
| 1 | July 13..... | Hot and dry... | Young leaves.. | 0.915 | 11.02 | 1.31 | 0 | Lower leaves slightly wilted; slight tip burn on some plants. |
| 2 | ..... | ..... | Old leaves..... | .845 | 10.18 | .74 | .31 | |
| 3 | ..... | ..... | Stems..... | 1.089 | 13.18 | 2.15 | 0 | |
| 4 | ..... | ..... | Tubers..... | .697 | 8.396 | .26 | 1.68 | |
| 5 | July 21, 9 a. m... | Hot and muggy | New leaves.... | .694 | 8.34 | .61 | 0 | Tip burn developed in past few days. |
| 6 | ..... | ..... | Old leaves..... | .747 | 7.78 | .74 | 0 | |
| 7 | ..... | ..... | Stems..... | .766 | 9.21 | 1.52 | 0 | |
| 8 | ..... | ..... | Tubers..... | .555 | 6.66 | .36 | 1.21 | |
| 9 | Aug. 7, 10 a. m.. | Dry, but showers on Aug. 8. | Foliage..... | .634 | 7.64 | ..... | ..... | Shaded plants grown in tiles. |
| 10 | ..... | ..... | Stems..... | .707 | 8.52 | ..... | ..... | |
| 11 | ..... | ..... | Tubers..... | .552 | 6.65 | ..... | ..... | |
| 12 | ..... | ..... | Foliage..... | .792 | 9.54 | ..... | ..... | Plants grown in tiles in the open. |
| 13 | ..... | ..... | Stems..... | .754 | 9.09 | ..... | ..... | |
| 14 | ..... | ..... | Tubers..... | .548 | 6.58 | ..... | ..... | |
| 15 | Aug. 13, 2.30 p.m. | Hot and dry... | Leaves..... | 1.047 | 12.60 | .84 | .71 | Leaves slightly wilted and yellow. |
| 16 | ..... | ..... | Stems..... | .735 | 8.85 | .40 | .14 | |
| 17 | ..... | ..... | Tips of tubers. | .672 | 8.10 | .12 | .46 | |
| 18 | ..... | ..... | Butts of tubers | .635 | 7.65 | .35 | .64 | |
| 19 | Aug. 13, 11 a. m.. | ..... | Leaves..... | .928 | 11.17 | .91 | .54 | Same as Aug. 12. |
| 20 | ..... | ..... | Stems..... | .667 | 8.02 | .36 | .28 | |
| 21 | ..... | ..... | Inside of tuber | .663 | 7.99 | .07 | .48 | |
| 22 | ..... | ..... | Outside of tuber. | .666 | 8.01 | .07 | .62 | |
| 23 | Aug. 18..... | Cloudy and warm. | Young leaves.. | .669 | 8.05 | .56 | 0 | Healthy plant. |
| 24 | ..... | ..... | Old leaves..... | .710 | 8.55 | .49 | .20 | |
| 25 | ..... | ..... | Stems..... | .865 | 10.42 | 1.80 | 0 | |
| 26 | ..... | ..... | Tubers..... | .544 | 6.55 | .62 | .32 | |
| 27 | ..... | ..... | Young leaves.. | .750 | 9.03 | .61 | 1.02 | Mosaic plant. |
| 28 | ..... | ..... | Old leaves..... | .791 | 9.52 | .70 | 0 | |
| 29 | ..... | ..... | Stems..... | .788 | 9.48 | 1.21 | 0 | |
| 30 | ..... | ..... | Tubers..... | .580 | 6.99 | .89 | 0 | |
| 31 | Aug. 21, 2 p. m.. | Clear; rain on Aug. 19 and 20. | Young leaves.. | .970 | 11.68 | .19 | 1.45 | Sample No. 1 from heavy clay loam soil, Randolph, Vt. |
| 32 | ..... | ..... | Old leaves..... | .811 | 9.77 | .03 | .80 | |
| 33 | ..... | ..... | Stems..... | .675 | 8.13 | .89 | 19 | |
| 34 | ..... | ..... | Tubers..... | .522 | 6.28 | 0 | .70 | |
| 35 | ..... | ..... | Young leaves.. | .980 | 11.80 | .19 | 1.48 | Sample No. 2, from another part of the same field. |
| 36 | ..... | ..... | Old leaves..... | .807 | 9.70 | .06 | .86 | |
| 37 | ..... | ..... | Stems..... | .676 | 8.15 | 0 | .54 | |
| 38 | ..... | ..... | Tubers..... | .572 | 6.88 | 0 | .60 | |
| 39 | Aug. 28, 3 p. m.. | Clear..... | Young leaves.. | .734 | 8.83 | .08 | .28 | Healthy plant. |
| 40 | ..... | ..... | Old leaves..... | .995 | 11.98 | .52 | 0 | |
| 41 | ..... | ..... | Stems..... | .680 | 8.19 | .38 | .47 | |
| 42 | ..... | ..... | Young leaves.. | .849 | 10.24 | .63 | .07 | Mosaic plant. |
| 43 | ..... | ..... | Old leaves..... | .967 | 11.64 | .69 | .04 | |
| 44 | ..... | ..... | Stems..... | .708 | 8.52 | .63 | 0 | |

TABLE II.—*Comparative cryoscopic readings in 1920*

| No. | Date. | Weather. | Variety and portion of plant. | Depression. | Depression in atmospheres. |
|---|---|---|---|---|---|
| 1 | July 2 | Partly cloudy and warm (4 p. m.) | White McCormick (mosaic): Young leaves | 0.648 | 7.81 |
| 2 | | | Stems | .626 | 7.54 |
| 3 | | | Pink McCormick (mosaic): Young leaves | .588 | 7.08 |
| 4 | | | Stems | .614 | 7.40 |
| 5 | | | Old seed piece | .614 | 7.40 |
| 6 | | | Dibble's Russet: Young leaves | .614 | 7.40 |
| 7 | | | Stems | .486 | 5.86 |
| 8 | | | Old seed piece | .492 | 5.93 |
| 9 | | | Early Rose (healthy): Young leaves | .573 | 6.90 |
| 10 | | | Stems | .582 | 7.01 |
| 11 | | | Old seed piece | .520 | 6.27 |
| 12 | July 11 | Bright and warm on 10th and 11th. | Burbank (healthy); coming into bloom: Young leaves | .664 | 8.00 |
| 13 | | | Stems | .697 | 8.40 |
| 14 | | | Dibble's Russet (healthy): young leaves | .782 | 9.44 |
| 15 | | | Stems | .654 | 7.88 |
| 16 | | | Old seed piece | .393 | 4.74 |
| 17 | July 14 | Hot and clear | Early Rose (planted June 25, plants just out of ground): Tops (all above ground) | .641 | 7.72 |
| 18 | | | Old seed piece | .639 | 7.68 |
| 19 | | | Dibble's Russet: Tops | .632 | 7.61 |
| 20 | | | Seed pieces | .539 | 6.49 |
| 22 | | | Burbank, full grown, in bloom; no tip burn: Leaf axis | .663 | 7.99 |
| 22 | | | Inside of leaflets | .723 | 8.71 |
| 23 | | | Outside of leaflets | .764 | 9.20 |
| 24 | July 23 | Hazy, clear, warm | Lamb's quarter: Growing tips and small leaves | 1.083 | 13.04 |
| 25 | | | Old leaves | .898 | 10.82 |
| 26 | | | Stems | .819 | 9.86 |
| 27 | July 27 | Bright, clear and cool; previous days same. | Dibble's Russet (some plants in bloom): Young leaves | .832 | 10.02 |
| 28 | | | Old leaves | .805 | 9.69 |
| 29 | | | Leaf stalks | .707 | 8.52 |
| 30 | | | Stems of plants | .838 | 10.09 |
| 31 | | | New tubers (size of hulled walnut) | .637 | 7.67 |
| 32 | | | Early Rose, some in bloom: Young leaves | .886 | 10.67 |
| 33 | | | Petioles and old leaves | .768 | 9.25 |
| 34 | | | Stems of plant | .791 | 9.53 |
| 35 | | | New tubers | .613 | 7.38 |
| 36 | July 28 | Clear and fairly hot | Lettuce, plants with short stalks: Leaves | .576 | 6.94 |
| 37 | | | stems | .638 | 7.69 |
| 38 | Aug. 4 | Clear and warm but not hot | Early Rose from garden; old leaves yellowing slightly: Young leaves | .832 | 10.02 |
| 39 | | | Old leaves | .729 | 8.79 |
| 40 | | | Stems | .693 | 8.35 |
| 41 | | | New tubers | .507 | 6.11 |
| 42 | Aug. 5, 3 p. m. | Hot and clear | Dibble's Russet: Young leaves | .948 | 11.42 |
| 43 | | | Old leaves | .727 | 8.76 |
| 44 | | | Stems | .789 | 9.50 |
| 45 | | | New tubers | .617 | 7.43 |
| 46 | Aug. 6, 3 p. m. | Hot and dry but no tip burn; atmosphere hazy. | Dibble's Russet: Young leaves | .883 | 10.64 |
| 47 | | | Old leaves | .813 | 9.79 |
| 48 | | | Stems | .884 | 10.65 |
| | | | New tubers | .626 | 7.54 |

TABLE II.—*Comparative cryoscopic readings in 1920*—Continued

| No. | Date. | Weather. | Variety and portion of plant. | Depression. | Depression in atmospheres. |
|---|---|---|---|---|---|
| 50 | Aug. 8, 3 p. m... | Hot and dry but hazy sunshine; 90° F.; no tip burn. | Dibble's Russet: Young leaves | 0.891 | 10.73 |
| 51 | ..... | ..... | Old leaves | .840 | 10.12 |
| 52 | ..... | ..... | Stems | .843 | 10.16 |
| 53 | ..... | ..... | Tubers | .631 | 7.60 |
| | | | Early Rose plants from garden; old leaves are yellow and dying: | | |
| 54 | ..... | ..... | Young leaves | .858 | 10.34 |
| 55 | ..... | ..... | Old leaves | .721 | 8.68 |
| 56 | ..... | ..... | Stems | .737 | 8.88 |
| 57 | ..... | ..... | Tubers | .622 | 7.49 |
| | | | Early Rose field plants: | | |
| 58 | ..... | No tip burn | Young leaves | .912 | 10.97 |
| 59 | ..... | ..... | Old leaves | .850 | 10.24 |
| 60 | ..... | ..... | Stems | .728 | 8.77 |
| 61 | ..... | ..... | Tubers | .633 | 7.63 |
| | | | Green Mountain: | | |
| 62 | Aug. 16..... | Hot, dry, clear; no tip burn as yet on these plants. | Young leaves | 1.028 | 12.38 |
| 63 | ..... | ..... | Old leaves | 1.088 | 13.10 |
| 64 | ..... | ..... | Stems | .940 | 11.32 |
| 65 | ..... | ..... | New tubers | .810 | 9.75 |
| | | | Green Mountain plants under shelter: | | |
| 66 | ..... | ..... | Young leaves | .926 | 11.15 |
| 67 | ..... | ..... | Old leaves | .881 | 10.61 |
| 68 | ..... | ..... | Stems | .860 | 10.36 |
| 69 | ..... | ..... | New tubers | .691 | 8.32 |
| | | | Tomato (Early Jewel): | | |
| 70 | Aug. 18..... | Hot and dry; brilliant sunshine; plants with large fruit. | Leaves | .715 | 8.61 |
| 71 | ..... | ..... | Old leaves (yellowing in most cases). | .613 | 7.38 |
| 72 | ..... | ..... | Stems | .581 | 7.00 |
| 73 | ..... | ..... | Green fruit | .562 | 6.77 |
| | | | Irish Cobbler, from another field: | | |
| 74 | ..... | Wind from north; cool in shade. | Young leaves | 1.117 | 13.44 |
| 75 | ..... | Some tip burn on these plants.. | Old leaves | 1.001 | 12.05 |
| 76 | ..... | ..... | Stems | .878 | 10.58 |
| 77 | ..... | ..... | New tubers | .648 | 7.81 |
| | | | Dahlia: | | |
| 78 | Aug. 19, 3 p. m.. | Hot and dry; potatoes show some tip burn. | Buds and tips of stalks.. | .665 | 8.01 |
| 79 | ..... | ..... | Leaves | .650 | 7.83 |
| 80 | ..... | ..... | Stems | .670 | 8.07 |
| 81 | ..... | ..... | Tubers | .818 | 9.85 |
| | | | Lettuce plants lengthening into stalks: | | |
| 82 | Aug. 19, 3 p. m.. | ..... | Stems | .920 | 11.08 |
| 83 | ..... | ..... | Leaves | .901 | 10.85 |
| | | | Green Mountain potatoes grown in open in tiles; all blossoms fallen: | | |
| 84 | Aug. 25..... | Fairly warm and bright; a little yellowing and tip burn on older leaves; none on younger leaves. | Young leaves | 1.061 | 12.77 |
| 85 | ..... | ..... | Old leaves | .964 | 11.61 |
| 86 | ..... | ..... | Stems | .947 | 11.40 |
| 87 | ..... | ..... | Tubers | .733 | 8.83 |
| | | | Green Mountain potatoes in tiles under shade: | | |
| 88 | ..... | A few old leaves show tip burn.. | Young leaves | .965 | 11.62 |
| 89 | ..... | ..... | Old leaves | .828 | 9.97 |
| 90 | ..... | ..... | Stems | .763 | 9.19 |
| 91 | ..... | ..... | Tubers | .681 | 8.20 |
| | | | Early Rose; no blossoms: | | |
| 92 | Aug. 27, 3 p. m.. | Hot and clear; fairly dry; plants of July 30, 6 to 8 inches high. | Foliage | .901 | 10.85 |
| 93 | ..... | ..... | Stems | .661 | 7.96 |
| 94 | ..... | ..... | Seed piece | .676 | 8.11 |
| | | | Green Mountain plants show buds 8 to 9 inches high: | | |
| 95 | ..... | ..... | Foliage | .820 | 9.87 |
| 96 | ..... | ..... | Stems | .705 | 8.49 |
| 97 | ..... | ..... | Seed piece | .421 | 5.07 |

TABLE II.—*Comparative cryoscopic readings in 1920*—Continued

| No. | Date. | Weather. | Variety and portion of plant. | Depression. | Depression in atmospheres. |
|---|---|---|---|---|---|
| 98 | .. | Hot and clear; fairly dry | Dahlia: Foliage | 0.695 | 8.37 |
| 99 | | | Stems | .702 | 8.46 |
| 100 | | | New tubers | .671 | 8.08 |
| 101 | Sept. 5 | Hot in sunshine; some haze | Artichokes from garden; growth had ceased: Young leaves and tips of stems. | .861 | 10.37 |
| 102 | | | Older leaves and petioles | 1.024 | 12.33 |
| 103 | | | Stems | .800 | 9.63 |
| 104 | | | Young tubers | .773 | 9.31 |
| 105 | Sept. 5 | Hot in sunshine; some haze; some tip burn; tubers over a pound in weight. | Dibble's Russet; no growing leaves. Medium-sized leaves of— Foliage | .803 | 9.67 |
| 106 | | | Stems | .648 | 7.81 |
| 107 | | | Tubers | .589 | 7.10 |
| 108 | Sept. 14, 3 p. m. | Cool and cloudy; rain for 3 or 4 days; plenty of tip burn and some blight; some yellow leaves. | Burbank: Foliage | .797 | 9.60 |
| 109 | | | Stems | .555 | 6.69 |
| 110 | | | Tubers | .553 | 6.66 |
| 111 | | | Dibble's Russet: Foliage | .856 | 10.31 |
| 112 | | | Stems | .481 | 5.80 |
| 113 | | | Tubers | .546 | 6.58 |

TABLE III.—*Readings in 1921; plants all grown in the greenhouse*

| No. | Date. | Remarks. | Variety and portion of plant used. | Depression. | Depression in atmospheres. |
|---|---|---|---|---|---|
| 1 | Mar. 22 | Plants 1 to 2 inches high | Burbank: Aerial portions | 0.494 | 5.95 |
| 2 | | | Seed piece | .557 | 6.71 |
| 3 | | | Roots | .464 | 5.59 |
| 4 | | | Early Rose: Aerial portions | .525 | 6.33 |
| 5 | | | Seed piece | .531 | 6.40 |
| 6 | | | Roots | .495 | 5.96 |
| 7 | Apr. 8 | | Burbank: Leaves | .586 | 7.06 |
| 8 | | | Stems | .525 | 6.33 |
| 9 | | | Seed piece | .527 | 6.35 |
| 10 | | | Early Rose: Leaves | .593 | 7.14 |
| 11 | | | Stems | .517 | 6.23 |
| 12 | | | Seed piece | .373 | 4.50 |
| 13 | Apr. 8 | Plants 8 to 10 inches high; new tubers size of pea. | Green Mountain: Leaves | .516 | 6.22 |
| 14 | | | Stems | .501 | 6.04 |
| 15 | | | Seed piece | .441 | 5.31 |
| 16 | | Plants just coming up | Sprouts | .554 | 6.68 |
| 17 | | | Seed piece | .609 | 7.25 |
| 18 | May 2 | Large plants past blossoming; some of old leaves yellow; new tubers, size of a hulled walnut. | Burbank: Young leaves | .656 | 7.90 |
| 19 | | | Old leaves | .506 | 6.10 |
| 20 | | | Stems | .607 | 7.31 |
| 21 | | | Seed piece | .300 | 3.62 |
| 22 | | | New tubers | .545 | 6.65 |
| 23 | | | Early Rose: Leaves | .783 | 9.43 |
| 24 | | | Stems | .627 | 7.55 |
| 25 | | | New tubers | .544 | 6.5 |

TABLE III.—*Readings in 1921; plants all grown in the greenhouse*—Continued

| No. | Date. | Remarks. | Variety and portion of plant used. | Depression. | Depression in atmospheres. |
|---|---|---|---|---|---|
| | | | Green Mountain: | | |
| 26 | May 31 | Hot in the greenhouse; the plants mature and yellowing; very hot on May 30. | Young leaves | 0.749 | 9.02 |
| 27 | | | Old leaves | .756 | 9.11 |
| 28 | | | Stems | .546 | 6.58 |
| 29 | | | New tubers | .496 | 5.02 |
| | | | Early Rose: | | |
| 30 | | Tubers large | Leaves | .703 | 8.47 |
| 31 | | | Stems | .644 | 7.76 |
| 32 | | | Tubers | .533 | 6.48 |
| | | | Burbank: | | |
| 33 | June 22 | Hot in the greenhouse; only a tuft of green leaves left on each branch; soil dry. | Leaves | .697 | 8.40 |
| 34 | | | Stems | .388 | 4.68 |
| 35 | | | New tubers | .497 | 5.99 |
| | | | Green Mountain: | | |
| 36 | | | Leaves | .778 | 9.37 |
| 37 | | | Stems | .498 | 6.00 |
| 38 | | | New tubers | .493 | 5.93 |

TABLE IV.—*Readings of plants all grown in the greenhouse in 1922*

| No. | Date. | Weather and remarks. | Variety and portion of the plant. | Depression. | Depression in atmospheres. |
|---|---|---|---|---|---|
| | | | Green Mountain: | | |
| 1 | Apr. 4 | Plants not over 1 to 12 inches high. | Sprouts | 0.651 | 7.84 |
| 2 | | | Seed pieces | .601 | 7.24 |
| | | | Early Rose: | | |
| 3 | | | Sprouts | .633 | 7.63 |
| 4 | | | Seed pieces | .533 | 7.42 |
| | | | Burbank: | | |
| 5 | | | Sprouts | .629 | 7.58 |
| 6 | | | Seed pieces | .563 | 6.78 |
| | | | Dibble's Russet: | | |
| 7 | | | Sprouts | .724 | 8.72 |
| 8 | | | Seed pieces | .583 | 7.02 |
| | | | Early Rose: | | |
| 9 | Apr. 27 | Plants show flower buds and young tubers. | Leaves | .893 | 10.73 |
| 10 | | | Stems | .741 | 8.92 |
| 11 | | | Seed pieces | .509 | 6.13 |
| | | | Dibble's Russet: | | |
| 12 | | | Leaves | .795 | 9.57 |
| 13 | | | Stems | .628 | 7.57 |
| 14 | | | Seed pieces | .491 | 5.92 |
| | | | Burbank: | | |
| 15 | | | Leaves | .778 | 9.37 |
| 16 | | | Stems | .737 | 8.88 |
| 17 | | | Seed pieces | .497 | 5.99 |
| | | | Green Mountain: | | |
| 18 | | | Leaves | .860 | 10.36 |
| 19 | | | Stems | .767 | 9.24 |
| 20 | | | Seed pieces | .630 | 7.59 |
| | | | Burbank: | | |
| 21 | June 27 | Hot and fair; tubers large with skin set; soil dry; old leaves yellow and beginning to die. | Young leaves | .895 | 10.78 |
| 22 | | | Older leaves | .828 | 9.97 |
| 23 | | | Upper stems | .758 | 9.13 |
| 24 | | | Lower stems | .590 | 7.11 |
| 25 | | | Seed pieces | .359 | 4.33 |
| 26 | | | New tubers | .576 | 6.94 |
| | | | Early Rose: | | |
| 27 | | | Young leaves | .822 | 9.90 |
| 28 | | | Old leaves | .771 | 9.29 |
| 29 | | | Upper stems | .769 | 9.26 |
| 30 | | | Lower stems | .666 | 8.02 |
| 31 | | | Seed pieces | .764 | 9.20 |
| 32 | | | New tubers | .529 | 6.37 |

TABLE IV.—*Readings of plants all grown in the greenhouse in 1922*—Continued

| No. | Date. | Weather and remarks. | Variety and portion of the plant. | Depression. | Depression in atmospheres. |
|---|---|---|---|---|---|
| | | | Green Mountain: | | |
| 33 | ..... | ..... | Young leaves | 0.991 | 11.93 |
| 34 | ..... | ..... | Old leaves | 1.010 | 12.05 |
| 35 | ..... | ..... | Upper stems | .808 | 9.73 |
| 36 | ..... | ..... | Lower stems | .752 | 9.06 |
| 37 | ..... | ..... | New tubers | .709 | 8.54 |
| | | | Dibble's Russet: | | |
| 38 | ..... | ..... | Young leaves | .950 | 11.44 |
| 39 | ..... | ..... | Old leaves | .953 | 11.48 |
| 40 | ..... | ..... | Upper Stems | .815 | 9.82 |
| 41 | ..... | ..... | Lower stems | .749 | 9.02 |
| 42 | ..... | ..... | New tubers | .631 | 7.60 |

TABLE V.—*Comparative cryoscopic readings in 1922*

| | | | | | |
|---|---|---|---|---|---|
| | | | Burbank: | | |
| 1 | July 12 | Hot and clear; 87° F., no tip burn | Young leaves | 0.706 | 8.504 |
| 2 | ..... | ..... | Old leaves | .725 | 8.732 |
| 3 | ..... | ..... | Stems | .718 | 8.65 |
| 4 | ..... | ..... | Old seed piece | .305 | 3.68 |
| 5 | ..... | ..... | New tubers | .581 | 7.00 |
| | | | Green Mountain: | | |
| 6 | ..... | Slight tip burn | Young leaves | .677 | 8.15 |
| 7 | ..... | ..... | Old leaves | .920 | 11.08 |
| 8 | ..... | ..... | Stems | .802 | 9.66 |
| 9 | ..... | ..... | New tubers | .555 | 6.69 |
| | | | Dibble's Russet: | | |
| 10 | ..... | Leaves all of same size on the plants; no tubers. | Young leaves | .691 | 8.32 |
| 11 | ..... | ..... | Old leaves | .761 | 9.17 |
| 12 | ..... | ..... | Stems | .659 | 7.94 |
| | | | Irish Cobbler: | | |
| 13 | July 26 | Bright and warm in sunshine, but cool in shade and at night. | Young leaves | .646 | 7.78 |
| 14 | ..... | ..... | Old leaves | .728 | 8.77 |
| 15 | ..... | ..... | Stems | .786 | 9.47 |
| 16 | ..... | ..... | New tubers | .565 | 6.81 |
| | | | Green Mountain: | | |
| 17 | ..... | ..... | Young leaves | .407 | 4.91 |
| 18 | ..... | ..... | Old leaves | .788 | 9.49 |
| 19 | ..... | ..... | Stems | .847 | 10.20 |
| 20 | ..... | ..... | New tubers | .481 | 5.60 |
| | | | Dibble's Russet: | | |
| 21 | ..... | ..... | Young leaves | .456 | 5.50 |
| 22 | ..... | ..... | Old leaves | .812 | 9.78 |
| 23 | ..... | ..... | Stems | .763 | 9.19 |
| 24 | ..... | ..... | New tubers | .506 | 9.10 |
| | | | Green Mountain: | | |
| 25 | July 27 | Hazy, bright, cool; plants grown in tiles and watered regularly. | Young leaves | .562 | 6.77 |
| 26 | ..... | ..... | Old leaves | .787 | 9.47 |
| 27 | ..... | ..... | Stems | .738 | 8.79 |
| 28 | ..... | ..... | New tubers | .439 | 5.29 |
| 29 | ..... | ..... | Old seed piece | .257 | 3.10 |
| 30 | ..... | Plants grown under a cloth shelter in tiles and watered regularly. | Young leaves | .357 | 4.30 |
| 31 | ..... | ..... | Old leaves | .613 | 7.37 |
| 32 | ..... | ..... | Stems | .698 | 8.41 |
| 33 | ..... | ..... | Seed pieces | .333 | 4.01 |
| 34 | Aug. 9 | Clear and bright but very cool; almost a frost preceding night. | Young leaves | .706 | 8.50 |
| 35 | ..... | ..... | Old leaves | .774 | 9.32 |
| 36 | ..... | ..... | Stems | .895 | 10.78 |
| 37 | ..... | ..... | New tubers | .540 | 6.51 |
| | | | Dibble's Russet: | | |
| 38 | ..... | ..... | Young leaves | .674 | 8.12 |
| 39 | ..... | ..... | Old leaves | .716 | 8.62 |
| 40 | ..... | ..... | Stems | .720 | 8.67 |
| 41 | ..... | ..... | New tubers | .476 | 5.74 |

TABLE V.—*Comparative cryoscopic readings in 1922*—Continued

| No. | Date. | Weather and remarks. | Variety and portion of the plant. | Depression. | Depression in atmospheres. |
|---|---|---|---|---|---|
| 42 | Aug. 15 | Very hot and sultry but hazy; very little tip burn. | Green Mountain: Young leaves | 0.663 | 7.99 |
| 43 | ..... | ..... | Old leaves | .789 | 9.50 |
| 44 | ..... | ..... | Stems | .789 | 9.50 |
| 45 | ..... | ..... | New tubers | .485 | 5.84 |
| 46 | ..... | ..... | Dibble's Russet: Young leaves | .752 | 9.06 |
| 47 | ..... | ..... | Old leaves | .700 | 8.43 |
| 48 | ..... | ..... | Stems | .708 | 8.53 |
| 49 | ..... | ..... | New tubers | .480 | 5.78 |
| 50 | Sept. 1 | Bright and fairly warm with the ground full of moisture; plants watered regularly. | Green Mountain: Young leaves | .856 | 10.31 |
| 51 | ..... | ..... | Old leaves | .794 | 9.60 |
| 52 | ..... | ..... | Stems | .746 | 8.99 |
| 53 | ..... | ..... | New tubers | .530 | 6.39 |
| 54 | ..... | Plants grown in tiles under a cloth shelter. | Young leaves | .672 | 8.09 |
| 55 | ..... | ..... | Old leaves | .796 | 9.59 |
| 56 | ..... | ..... | Stems | .791 | 9.53 |
| 57 | ..... | ..... | New tubers | .568 | 6.84 |

## SUMMER OF 1919

The cryoscopic readings taken in the summer of 1919 were not as numerous as those made in 1918 and were all on one variety, Green Mountain. Unfortunately, no readings were made in early July, and by the time the first juices were frozen the plants were already coming into blossom. It will be noted that on July 13, and again on July 21, the juice content of the stem was higher than that of any other part of the plant. Moreover, on August 13, which was a hot dry day, giving the leaf juice a greater depression, the leaves were in a state of incipient wilt.

The juices from various portions of the tuber tip, as compared with those of the butt, or those of the inside compared with those of the outside, do not seem to vary much in their cryoscopic readings, as can be seen from the reading on August 13.

The greater depression of the juice from the aerial portions of plants grown in shade, is to be noted on August 7, while mosaic plants gave greater depressions from the foliage portions on August 18 and on August 28. The mosaic stems, however, showed a reverse condition.

One of the most interesting sets of observations is that made on potatoes from Randolph, Vt. The field from which these plants were obtained is in one of the best potato regions in the northern United States, and the plants themselves were in splendid condition, without a trace of tip burn and still actively growing. It will be noticed that the juice from the young leaves has a markedly large depression, a fact that in the 1918 observations was associated with continued or renewed growth.

SUMMER OF 1920

The difference in the date of the death of the plants in early and late varieties must lie in some factor internal to the plant itself. Differences of osmotic pressure in the various parts of the plant at various stages of growth might give some clue to the early loss of foliage and ripening of the so-called early types. Very early and very late varieties of potatoes were planted, therefore, and tests were made on them at various stages during the growing season. The McCormick Pink and White variety (reputed to be very resistant to hot weather and tip burn), from which some differences in osmotic pressure might have been expected as compared to early varieties that succumb prematurely to tip burn, was a disappointment. The plants very early showed pronounced symptoms of mosaic and only one cryoscopic reading was taken of the juices.

The season was a favorable one, as it presented a contrast to the two preceding years in the weather and in the time of the appearance and the amount of tip burn. The official charts do not show any great contrast in temperature, sunshine, and rainfall, but the effect on the plants was not the same, owing to the fact that much haze and humidity nearly always tempered extreme periods of heat and sunshine. The rainfall during June and July was almost 2 inches above normal, while that of August was 1.64 inches below normal. The rain was well distributed throughout the month, however. The plants grew large and succulent and tubers developed rapidly. The foliage was so extreme and covered the ground between 3-foot rows so densely that it was impossible to avoid stepping on the vines. Tip burn was practically absent until late in the season, after which it advanced fairly rapidly, owing to the rank growth. The tip burn was first noted about August 19, almost a month later than it usually appears here.

The results from the cryoscopic readings of the juices of the potato and other plants in general confirm in the following particulars those taken during 1918:

1. The young growing portions of the plant contained juice with a somewhat higher osmotic pressure than the stems and a very much greater pressure than the old seed piece.

2. The pressure in all parts of the plant is comparatively low during the early growth of the plants, rising to a maximum during August and dropping away during September.

3. The marked differences shown in the freezing points of the juice from various parts of the potato plant do not seem to be shown by the dahlia or artichoke.

The results in 1920, however, do not agree with those of 1918, since in 1918 the stems developed much higher osmotic pressures than the leaves just at the time that foliage growth had ceased and tuber formation begun. The foliage juice at all times in 1920 showed a greater pressure than the juice from the stems, although there were times when it was almost the same.

A few comments on the readings and tables, to bring the facts together, will make the relations a little clearer.

Dibble's Russet (a late variety) and Early Rose are the only varieties of which a fairly complete record was obtained during the critical portions of the growing season. Tables VI and VII summarize the readings.

TABLE VI.—*Comparison of juices from Dibble's Russet during the summer*

| Dibble's Russet. | July 2. | July 12. | July 27. | Aug. 6. | Aug. 8 | Sept. 5. | Sept. 14. |
|---|---|---|---|---|---|---|---|
| Leaves | 0.614 | 0.782 | 0.832 | 0.883 | 0.891 | 0.803 | 0.856 |
| | ..... | ..... | .805 | .813 | .840 | ..... | ..... |
| Stems | .486 | .654 | .838 | .884 | .843 | .648 | .481 |
| Old seed piece | .492 | .393 | ..... | ..... | ..... | ..... | ..... |
| New tubers | ..... | ..... | .637 | .626 | .631 | .589 | .546 |

TABLE VII.—*Comparison of juices of Early Rose under various conditions*

| Early Rose. | Planted June 25. | | | Garden sandy soil, Aug. 4. | Garden sandy soil, Aug. 8. | Field clay soil, Aug. 8. | Plants of July 3, Aug. 27. |
|---|---|---|---|---|---|---|---|
| | July 2. | July 14. | July 27. | | | | |
| Leaves | 0.573 | 0.641 | 0.886 | 0.832 | 0.858 | 0.912 | 0.901 |
| | ..... | ..... | .768 | .729 | .721 | .850 | ..... |
| Stems | .533 | ..... | .791 | .693 | .737 | .728 | .661 |
| Old seed piece | .520 | .639 | ..... | ..... | ..... | ..... | .676 |
| New tubers | ..... | ..... | .613 | .507 | .622 | .633 | ..... |

The Dibble's Russet does not show such a marked falling off in osmotic pressure in the foliage juices after the heavy rains of September as might be expected, but the juice of the stems, especially according to the reading of September 14, did not produce much depression. The maximum readings were obtained on the juice of the younger leaves on August 6 and 8. It will be noticed that the depression from the juice of the stems on July 27 and August 6 and 8 almost equaled that of the young leaves and exceeded that of the older leaves; on July 2, when the plants were younger, the depression from the stem juice was much less than that from the juice of the leaves.

The Early Rose followed in general the same general course of increase in the atmospheric pressure of the sap until a maximum was reached during late July and early August. Unfortunately, no reading was made in late August after the plants had started to decline. The juice of the stems of this variety never approximated that of the foliage in producing freezing point depressions. The nearly similar depressions observed for the juices obtained from the various parts of the plants grown on sandy soil and on heavy clay soil are to be noted. The potatoes on the sandy soil were somewhat more advanced and the older leaves had begun to turn yellow, which will explain the comparatively small depression produced by the juice of these leaves on August 4 and 8; the old leaves had already begun to decline and the material to be withdrawn into the stem. The plants used on August 27 were planted on July 3, and are not comparable. On that date, they showed about the same atmospheric depressions in the juice from the various parts as the plants used on August 8.

The difference in osmotic pressure in the juices of plants raised under shade as compared with those grown in the open is shown in Table VIII.

TABLE VIII.—*Effect of shade on osmotic pressures in the juices*

(Green Mountain, Aug. 25, 3 p. m.)

| Portion of plant used. | Plants in open. | Plants under shade. |
|---|---|---|
| Young leaves | 1.061 | 0.965 |
| Old leaves | .964 | .828 |
| Stems | .947 | .763 |
| Tubers | .733 | .681 |

The Green Mountain plants used for the above experiment were grown in large tiles, half of them shaded with a heavy cotton cloth which cut off at least 50 per cent of the light. A comparison of the readings will show that while the plants grown in the open exhibited a greater depression in the young leaves and tubers, the greatest difference was shown in the readings obtained from the old leaves and stems, especially the latter. The older leaves on the open-air plants were beginning to suffer from tip burn at the time of this experiment in spite of the very great osmotic pressure, while those in the shade were practically untouched. The high pressure in the juice of the open-air stems is probably the result of the very much superior starch assimilation which the leaves of these plants were carrying on.

A few observations were made on plants other than potatoes, for purposes of comparison. Lamb's quarter, on July 23, showed about the same relations as to osmotic pressure as did the potato plant. The pressure at this time, however, was above that obtained on July 14 and 27 for potatoes. Lettuce, examined on July 28, gave comparatively low pressures; the plants were still succulent and tender, with only a very short stalk. Sap from tomato plants examined on August 18 showed much less osmotic pressure than sap obtained from the various parts of the potato plants used on the same day. However, these particular potato plants were beginning to show tip burn. These readings are comparable to those obtained in 1918 from tomato, but the plants in that year were taken very much later and after cold rains, and were consequently much lower. Lettuce, examined August 19, was tried again after the plants had begun to lengthen into flower stalks, but no marked difference is to be noted in the stem and leaf juice atmospheric pressure, although it is much higher than it was at the time of the earlier reading on July 28.

Dahlias and artichokes should show some of the same internal physiological conditions as the potato plant, but it must be remembered that the tubers from them are swollen roots, and not enlarged underground stems. The pressures in the dahlia plant, examined August 27, are practically at an equilibrium, but the new tubers show the least pressure. The pressure in this plant seems to be much less than it was in the Early Rose and Green Mountain potato plants taken from adjoining rows. The readings on the artichoke plants on September 5, taken on a hot day and after the plant growth had ceased, showed very much higher pressures than those of the dahlia plant—in fact, they are comparable to those from the potato plant. This apparent anomaly shows that the juice of the older leaves has higher pressure than that of the younger leaves and tips of the stems. The juices of tubers have a comparatively high pressure, but the lowest of any of the juices in the plant.

All the juices of the tubers produced during the year 1920 seem to show a much higher osmotic pressure than those of 1918. No cause for this difference is apparent. It is consistent throughout the season, however, and so must be due to the particular weather conditions of that summer.

## SUMMER OF 1922

The year 1922 was marked by the wettest June on record, so that it is interesting to see the effect such a period would have on the juice of the plants. On July 12 the juice of the old leaves had the greatest depression, an observation that had not been made before. The leaves at this date were all of one size, but, as the plants were in bud, the formation of new leaves and branches had ceased, and whatever growth was going on was in the form of an increase in the size of the older leaves. It is probable that all material was actually being removed from the tip (smaller) leaves as it was synthesized, and was utilized in other parts of the plant. On July 26, two weeks later, however, the juice of the stems of the Irish Cobbler and Green Mountain varieties had a very much greater depression, but the Dibble's Russet still showed more in the old leaves. The old leaves were of almost the same sizes as the tip leaves in their variety.

The plants grown under a shade showed on July 17 a lower osmotic pressure in all parts except the tubers than did those grown outside and watered regularly, so that the ground was almost moist. On September 1, however, there was not very much difference between the plants grown in the open and those in the shade.

The observations made on August 9 are of interest on account of the coolness of the preceding night, when the temperature sank below 40° F. The highest pressure seemed to be in the stems, especially in the Green Mountain variety. Not much change can be seen in the readings for August 15, although the weather then was hot and sultry.

## GENERAL RESULTS FOR 4 YEARS

A considerable diversity has been shown in the character of the seasons, especially with regard to the amount of rainfall during the 4 years in which these cryoscopic readings have been made on the potato plants. The wet years were 1918 and 1922, while 1919 and 1920 were inclined to be dry, especially the early part of the growing season of 1919. Tables IX and X show all the data obtained from various varieties of potatoes.

TABLE IX.—*Comparison of juices from Green Mountain plants during four years*

| Portion of potato used. | July 20, 1918. | July 21, 1919. | July 27, 1920. | July 26, 1922. |
|---|---|---|---|---|
| Young leaves | 8. 07 | 8. 34 | 10. 02 | 4. 91 |
| Old leaves | 7. 84 | 7. 78 | 9. 69 | 9. 49 |
| Stems | 8. 07 | 9. 21 | 10. 09 | 10. 20 |
| New tubers | 6. 10 | 6. 66 | 7. 67 | 5. 60 |

| Portion of potato used. | Sept. 1, 1918. | Aug. 31, 1919. | Sept. 5, 1920. | Aug. 15, 1922. |
|---|---|---|---|---|
| Young leaves | ..... | 9. 80 | ..... | 7. 99 |
| Old leaves | 9. 75 | 8. 07 | 9. 67 | 9. 50 |
| Stems | 8. 98 | 8. 15 | 7. 81 | 9. 50 |
| New tubers | 6. 16 | 6. 88 | 7. 10 | 5. 84 |

TABLE X.—*General average on juices of Green Mountain variety during four years*

| Portion of potato used. | 1918 | 1919 | 1920 | 1922 |
|---|---|---|---|---|
| Young leaves | 7. 54 | 9. 90 | 10. 41 | 7. 04 |
| Old leaves | 6. 59 | 10. 03 | 10. 20 | 9. 19 |
| Stems | 8. 74 | 9. 14 | 8. 97 | 8. 56 |
| New tubers | 6. 30 | 7. 08 | 7. 52 | 6. 18 |

It will be noticed that the readings for 1918 and 1922 are lower than those of 1919 and 1920, and that this difference is even reflected in the atmospheric pressure in the new tubers themselves. The high pressure in the stems (as compared to that from other portions of the plant) during 1918, and that in the old leaves during 1922, are other peculiar features.

## POTATO PLANTS GROWN IN THE GREENHOUSE, 1921 AND 1922

The almost complete freedom of greenhouse grown plants from physiological tip burn and the fact that such plants will continue to remain green and to continue growth ought to make the osmotic pressures of interest as compared with those from the field.

The osmotic pressure in the young sprouts that come from the seed piece is generally higher than that of the seed piece itself, but an exception was to be noted in the Burbank and Early Rose on March 22, 1921, and in the Green Mountain on April 18. The osmotic pressure in the seed piece drops away rapidly as the stored starch is used by the plant, but an exception again occurs in the Green Mountain seed pieces on April 27, and the Early Rose on June 27, where the pressure continued high. The dry condition of the soil may explain this high pressure, as the water may have passed out of the seed piece, gradually leaving a more concentrated solution behind, or the plant may have been unable to supply water to the seed piece to remove the sugars which went into solution. The soil was very dry and probably drier in some beds than in others.

The roots examined March 22, 1921, had the lowest osmotic pressure of any portion of the growing plants, as was to be expected.

It may be noted generally for both years that the foliage maintained at all times a greater osmotic pressure than any other organ of the plant. In general, the pressures in younger tip leaves were greater than in the older leaves, but there were exceptions. The juice of the stems, however, at no time approached that of the foliage, and in this relation we have something radically different from the conditions in plants grown in the field where, at some time during the growing season, the stems always developed a higher pressure than the leaves. The high stem pressures came usually at the periods of tip burn, and the author is inclined to associate the two phenomena. While the plant is very active photosynthetically the sugars that are so rapidly formed are stored temporarily in the stem to the detriment of the leaves of the plant. Shaded plants, greenhouse plants, and the plants from Randolph, Vt., did not show this abnormally high stem pressure and did not show any amount of tip burn. The two sets of facts may be unrelated, but the common occurrence is at any rate highly suggestive that they are connected.

The pressure developed in the young tubers in the greenhouse is like that in tubers grown out of doors. The average for the young tubers for both years is 6.60 atmospheres in the greenhouse plants of all sorts, compared with 6.30, 7.08, 7.52, and 6.18 atmospheres in new tubers from the field in the four years during which the work was carried on. The very dry condition of the soil in the benches undoubtedly helped to raise the pressure in the tubers grown in such soil.

## SUMMARY

(1) The general results confirm those obtained in 1918; the growing portions, usually the young leaves and branches, have a higher osmotic pressure in their cell sap than in the sap of the old leaves, stems, or new tubers.

(2) The growth of the top leaves may be checked, however, and the lower (older) leaves may show a very much greater pressure.

(3) The stems usually show the highest pressure during the height of the activity of the plant (July 15 to August 20), apparently because of the presence of a high percentage of reducing sugars.

(4) Potato plants taken from fields in one of the best potato regions in the northern States (Randolph, Vt.), even at the height of the plant activity, showed superior pressure in the young leaves and shoots and the plants were apparently still growing at that time, without any signs of tip burn.

(5) Plants grown in tiles under a cloth shade have less osmotic pressure in the juices of the foliage parts as compared with plants grown in tiles in the open; the pressure in the stems and tubers is about the same, however.

(6) No differences could be detected in the juices from the early and late varieties. Weather seemed to have more effect than variety.

(7) Mosaic plants have a higher osmotic pressure in the leaves than healthy ones, but this does not seem to be true of the stems.

(8) The osmotic pressure is greater in some years than in others, depending on the weather; a wet year lowers the pressure while a dry one raises it, especially in the new tubers.

(9) The pressure varies much more between different parts of the potato plant than it does between those of the artichoke or dahlia; the potato seems to be in a state of unstable equilibrium. The older leaves of the artichoke may have a very high pressure, but the dahlia seems to be quite constant throughout, even in very warm, clear sunshine.

(10) Potato plants grown in the greenhouse never developed a superior osmotic pressure in the stems; the pressure in the leaves was always much higher. The osmotic pressure in the new tubers was about the same as that of field-grown plants, probably because of the rather dry condition of the soil.

# A METHOD FOR THE QUANTITATIVE ESTIMATION OF TANNIN IN PLANT TISSUE[1]

By PAUL MENAUL[2]

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A search of the literature on the subject reveals no method by which small amounts of tannin may be estimated in plant tissue. Since a study of the chemistry of the grain sorghums was being made by the author, it was decided to estimate the tannin content of the grains. The method employed and the results obtained are given in this article.

## COLOR REAGENT

The color reagent is made by boiling 100 gm. of pure sodium tungstate, 30 gm. of pure arsenic acid ($As_2O_5$) with 300 cc. water and 50 cc. concentrated hydrochloric acid for two or three hours under a reflex condenser. The solution is then cooled and diluted to 1 liter. This reagent is not affected by phenols or proteins nor is it affected by dextrose, and the color produced by tannic acid is stable for an hour. Since the color reagent used is sensitive to many reducing agents, it must be kept away from hydrogen sulphid and other reducing reagents. This color reaction is not specific for tannins, but it is evident that tannins are the only compounds left in the final solution which will affect the color reagent.

## PROCEDURE

Grind the sample to pass a No. 40 mesh. Extract 20 gm. of the sample in a 300 cc. Erlenmeyer flask with 100 cc. of petroleum ether, stopper and shake occasionally, and allow to stand overnight. Then filter through a dry filter and wash with 100 cc. of petroleum ether in 20 cc. portions. Dry the sample, return it to the flask, and treat with 200 cc. of 95 per cent alcohol. Shake from time to time and allow to stand about 16 hours. Again filter through a dry filter. This method of extraction is described by H. C. Fuller in his "Chemistry and Analysis of Drugs and Medicines."[3] Now take 10 cc. of this filtrate in a urine centrifuge tube, add 2 cc. of a 10 per cent solution of lead acetate, place in water heated to about 75° C., and leave until the precipitate coagulates. Centrifuge for three minutes, then pour off the supernatant liquid and drain as completely as possible. Add from 5 to 10 drops of 5 per cent $H_2SO_4$ to the residue and mix thoroughly. Too much sulphuric acid is to be avoided, but enough must be added to dissolve the lead tannate and to precipitate the lead completely. Pour in enough water almost to fill the tube, stir, and centrifuge for three minutes. Transfer the supernatant liquid to a 50 cc. or 100 cc. volumetric flask and at the same time prepare as a control a similar flask containing 1 mgm. or 2 mgm. of pure

[1] Accepted for publication July 18, 1923.

[2] The possibility of finding a practical colorimetric method for the determination of tannins was suggested to the author by Dr. C. T. Dowell, director of the station and station chemist.

[3] FULLER, Henry C. THE CHEMISTRY AND ANALYSIS OF DRUGS AND MEDICINES. ix, 1,072 p., illus. New York. 1920.

gallotannic acid from which the gallic acid has been extracted with ether. Add 2 cc. of the color reagent to each tube, then 10 cc. of a 20 per cent solution of $Na_2CO_3$; dilute the contents to volume and allow to stand five minutes. Compare the colors and calculate the amount of tannin in the sample.

Known amounts of tannin were carried through this procedure, and the color developed compared with the standard tannin solution was found to be very close to 100 per cent. If, however, gallic acid was present, it was not carried through quantitatively.

Since 20 gm. samples were taken and the tannin was extracted with 200 cc. of alcohol, 10 cc. of the filtrate represent the tannin extracted from 1 gm. of sample.

The percentages of tannin in the sorghums determined by the foregoing method were found to be as follows:

| Variety of sorghum: | Per cent. |
|---|---|
| Dawn | 0.06 |
| Darso | .4 |
| White Kafir | Trace. |
| Hagairi | .15 |
| Black Amber | .2 |
| African Millet | .27 |
| Club Head Sorgo | .16 |
| Orange Cane | .5 |
| Broom Corn | .4 |
| Yellow Maize | Trace. |
| White Maize | None. |

# A CHEMICAL ANALYSIS OF JATROPHA STIMULOSA[1]

By PAUL MENAUL

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The seed of *Jatropha stimulosa*, commonly called the spurge nettle, are regarded by those who have the courage and patience to gather them, as an excellent article of food. A chemical examination will give a clearer understanding of their nutritive properties.

In appearance the seeds resemble those of the castor bean. Each is composed of 39 per cent hull and 61 per cent kernel. An analysis of the kernel yields the following results:

| | Per cent. |
|---|---|
| Water | 1.58 |
| Ash | 3.50 |
| Protein | 33.3 |
| Fiber | 2.9 |
| Nitrogen free extract | 7.81 |
| Fat | 50.91 |

The oil was extracted by pressure. It is a clear yellowish, semi-drying fluid of somewhat less viscosity than castor oil, and the taste is mild and pleasant.

An analysis of the oil gives the following results:

| | |
|---|---|
| Specific gravity | 0.9257 at 15.6 °C. |
| Refractive index | 1.4765 at 15.6 °C. |
| Solidifying point | Below—15 °C. |
| Iodin No | 124.65 to 129.47. |
| Saponification No | 186.4 to 186.56. |
| Volatile fatty acids | None. |
| Free fatty acids | Trace. |
| Fatty acids | 95.6 per cent. |
| Glycerin (about) | 4.2 per cent. |

When separated by the solubility of their lead soaps in cold benzene, the fatty acids of the oil were found to consist of saturated fatty acid 15.4 per cent and of unsaturated fatty acid 83.6 per cent. After the oil was completely extracted from the meal by ether the character of the protein was examined. The solubility of the protein in various solvents is shown in the following table. The meal was ground to 100 mesh and extracted with the various solvents in the proportion of ten cc. of solvent to one gram of meal. These mixtures were allowed to stand for five hours with frequent shaking. Nitrogen determinations were made on the clear filtrates.

[1] Accepted for publication July 18, 1923.

*Extraction of protein by various solvents*

| Solvent. | Total protein extracted. |
|---|---|
| | *Per cent.* |
| Distilled water | 0 |
| 5 per cent NaCl | 24.2 |
| 10 per cent NaCl | 32.68 |
| 15 per cent NaCl | 12.11 |
| 2.5 per cent HCl | 73.3 |
| 2 per cent $Na_2CO_3$ | 78.72 |

The protein is precipitated from its saline extract by dialysis. Analyses of the protein by the Van Slyke method were made, using the protein extracted by 10 per cent NaCl and also the protein prepared by extracting with alkali and precipitating by the addition of acid—a method previously suggested by Dowell and Menaul.[3]

*Distribution of the nitrogen in Jatropha stimulosa as determined by the Van Slyke method*

| Form in which nitrogen was found. | Nitrogen extracted with solvent named. | | | |
|---|---|---|---|---|
| | NaCl Sol. | 0.2 per cent NaOH. | NaCl. Sol. | 0.2 per cent NaOH. |
| | *Mgm.* | *Mgm.* | *Per cent.* | *Per cent.* |
| Total nitrogen | 520 | 445 | ..... | ..... |
| Amid N | 58.60 | 48.95 | 11.27 | 11.00 |
| Humin N | 10.97 | 10.5 | 2.11 | 2.36 |
| Cystin N | Trace. | Trace. | Trace. | Trace. |
| Arginin N | 74.88 | 64.04 | 14.4 | 14.39 |
| Histidin N | 64.48 | 56.12 | 12.4 | 12.61 |
| Lysin N | 23.97 | 20.00 | 4.61 | 4.5 |
| Total N of amino acids | 287.72 | 243.69 | 55.33 | 54.76 |
| Total | 520.62 | 443.3 | 100.12 | 99.62 |

Tryptophan—present.

The seeds of Jatropha stimulosa are composed largely of fat and protein. The fat contains a high percentage of unsaturated fats and the protein contains a high percentage of histidin.

[3] DOWELL, C. T., and MENAUL, Paul. NITROGEN DISTRIBUTION OF THE PROTEINS EXTRACTED BY DILUTE ALKALI FROM PECANS, PEANUTS, KAFIR, AND ALFALFA. *In* Jour. Biol. Chem., v. 46, p. 437-441. 1921.

# VARIETAL RESISTANCE IN WINTER WHEAT TO THE ROSETTE DISEASE[1]

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## INTRODUCTION

It is known that heavy crop losses due to the rosette disease of wheat can be avoided by the use of resistant varieties and selections, as shown by McKinney,[2] from experiments conducted during the crop years 1919–20 and 1920–21. Certain varieties, notably Early May and Turkey, were found to be apparently free from the rosette symptoms, while Harvest Queen (known also as Red Cross and Salzer's Prizetaker) and Illini Chief showed an exceedingly high percentage of the disease.

The experiments were continued in the crop year 1921–22, when over 200 varieties and selections [3] of winter wheat from all parts of the United States were tested by the Office of Cereal Investigations, Bureau of Plant Industry, United States Department of Agriculture, in cooperation with the Illinois and Indiana Agricultural Experiment Stations. It is the purpose of this paper to present briefly the data thus obtained.

## METHODS OF EXPERIMENTATION

The varietal experiments reported in this paper were conducted during the crop year 1921–22 near Granite City, Ill., and near Wanatah, Ind., on as uniformly infested land as it was possible to obtain. The methods employed at both stations were essentially the same, and one description will serve for both, exceptions being noted when they occur.

During the early autumn the soil was deeply plowed and thoroughly harrowed. In Indiana the sowing was started on September 29, 1921, and in Illinois on October 8, 1921. Furrows were opened by means of a wheel hoe, the grain sown by hand at the rate of 1 gram per linear foot, and covered with a rake. The varieties were sown in single rows 8 inches apart and 1 rod long. The seed for most of the varieties was supplied by the Office of Cereal Investigations. Other varieties, used only at Wanatah, Ind., were supplied by the Indiana Agricultural Experiment Station. A susceptible variety, Harvest Queen, was sown in every tenth row throughout the series to serve as a control on the uniformity of infestation of the soil. Seed of this variety was obtained from a field free from the rosette disease.

This susceptible variety will hereafter be called Harvest Queen. It is awnless and has white, glabrous chaff and red kernels. It is sometimes called Red Cross, sometimes Harvest Queen, and is known locally in Madison County, Ill., as Salzer's Prizetaker. All of these appear to be

[1] Accepted for publication Aug. 11, 1923. Results of research conducted cooperatively by the Bureau of Plant Industry, United States Department of Agriculture, and the Illinois and Indiana Agricultural Experiment Stations.

[2] MCKINNEY, H. H. INVESTIGATIONS ON THE ROSETTE DISEASE OF WHEAT AND ITS CONTROL. *In* Jour. Agr. Research v. 23, p. 771–800, 2 fig., 8 pl. 1923. Literature cited, p. 799–800.

[3] These varieties and selections will hereafter be referred to as "varieties."

one and the same variety. The name Salzer's Prizetaker is incorrectly applied to this variety, inasmuch as the original variety of this name has brown chaff and white kernels. There is also another variety known as Red Cross (belonging to the Red May group) which has brown chaff and red kernels, and which is resistant or only slightly susceptible to the rosette disease. For these reasons the name Harvest Queen has been adopted, this being the name under which the variety is most often grown.

## RESULTS OBTAINED

The plants emerged in a few days after sowing, a good stand was obtained, and the plants were very vigorous. No signs of the rosette disease could be detected in the autumn and the plants passed into the dormant period in good condition. However, conspicuous differences developed early in the spring and continued throughout the season. As usual, several varieties proved very susceptible, a few proved only slightly susceptible, and the remaining large number of varieties proved highly resistant to rosette.

The first symptom to appear, as in previous years, was the retardation in development of the plants. Excessive tillering followed and at a later stage stunting was apparent, accompanied by an abnormally dark green color of the leaves. Other symptoms developed subsequently, as described more fully by McKinney.[4] The data on the series in Illinois were recorded by H. H. McKinney on April 20, 1922. In Indiana preliminary data were taken by H. H. McKinney and H. S. Jackson on April 21, 1922, and final data were taken by J. B. Kendrick and R. W. Webb on May 14, 1922. The results are given in Tables I and II, which include the final data only.

## VARIETIES SUSCEPTIBLE TO ROSETTE

The susceptible varieties, arranged according to classes, are presented in Table I. The Cereal Investigations (C. I.) accession number, or other source of seed, and head descriptions are given for each variety. The percentage of plants infected in each variety was determined on the basis of macroscopical symptoms of the disease.

The relatively small number of varieties that show a high degree of susceptibility is very striking. The varieties "Brunswick," Nigger, Penquite (Velvet Chaff), Missouri Bluestem, Harvest Queen, Selection from Indiana Swamp, Fultz (Kentucky Agricultural Experiment Station Selection), Miller's Pride, and Illini Chief are highly susceptible. These susceptible varieties represent only 4 per cent of the total number of varieties tested.

These results agree very closely with those obtained in previous years and reported by McKinney.[4] However, there are two outstanding deviations. For instance, Nigger appeared resistant in 1921 and highly susceptible in 1922, and Niagara showed a susceptibility of 70 per cent in 1921 and less than 2 per cent in 1922. Although only 4 per cent of the varieties reported in this paper are classified as extremely susceptible, this represents a greater number of varieties than previously has been shown susceptible to the disease.

[4] McKinney, H. H. op. cit.

TABLE I.—*Varieties of winter wheat found susceptible to the rosette disease, in experiments conducted in the crop year 1921–22, at Granite City, Ill., and at Wanatah, Ind., grouped according to classes, with head characters for each and percentages of infection*

| Variety. | C. I. number, or source. | Head characters.[a] | Percentage of plants infected. | |
|---|---|---|---|---|
| | | | Granite City, Ill. | Wanatah, Ind. |
| Hard Red Winter: | | | | |
| Pesterboden— | | | | |
| Budapest | 5789 | BWG. | [b] T. | T. |
| Turkey— | | | | |
| Malakof | 4898 | BWG. | [b] 0 | T. |
| Soft Red Winter: | | | | |
| Alabama (Wis. No. 81) | 5785 | AWG. | 0 | T. |
| Brown Bearded | 3118 | BRG. | 0 | 2 |
| "Brunswick" [c] | Ind. Sta | | [b]— | 98 |
| China— | | | | |
| Pennsylvania Bluestem. | 5342 | ARG. | 0 | 1 |
| Currell | 3326 | ARG. | 0 | T. |
| Fulcaster— | | | | |
| Stoner (Marvelous) | 3605 | BWG. | 0 | T. |
| Fultz | 5308 | AWG. | — | 2 |
| Do | 3598 | AWG. | 0 | 1 |
| Do | 1923 | AWG. | 0 | T. |
| Fultz (Kentucky Selection). | 6896 | AWG. | 80–90 | 45 |
| Gipsy— | | | | |
| Niagara | 5307 | BWG. | 1–2 | 0 |
| Harvest Queen (Control) | Granite City, Ill. | AWG. | 95–100 | 55 |
| Harvest Queen | 4882 | AWG. | 95–100 | 30 |
| Do | Kans. Sta | AWG. | 95–100 | — |
| Harvest Queen— | | | | |
| Kessinger | Ind. Sta.[d] | AWG. | — | 5 |
| Illini Chief | 5956 | ARG. | 5–10 | 25 |
| Do | Ind. Sta | ARG. | — | 1+ |
| Jones Fife | Ind. Sta. (R. 25) | AWV. | — | 3 |
| Do | Ind. Sta. (R. 13) | AWV. | — | 1+ |
| Leap | 5618 | AWG. | 0 | T. |
| Mediterranean | 3332 | BRG. | 0 | T. |
| Do | 3467 | BRG. | 0 | T. |
| Mediterranean— | | | | |
| Miller's Pride | 4865 | BRG. | 75 | 20 |
| Missouri Bluestem | 1912 | BRG. | 95–100 | 75 |
| Nigger | 5366 [e] | BWG. | 95–100 | 90 |
| Penquite (Velvet Chaff) | 3068 | BRV. | 95–100 | 75 |
| Poole | 5653 | ARG. | 0 | 1 |
| Red May— | | | | |
| Enterprise | 3399 | ARG. | 0 | T. |
| Red Cross | 5318 | ARG. | 0 | 1–2 |
| Sel. from Ind. Swamp | 4834 | BRG. | 95–100 | 40 |
| Do | 3334 | BRG. | 1 | T. |
| Selection No. 13631 | 4081 | AWG. (Club.) | 1–2 | 2 |
| Selection No. 131156 | 4808 | BRG. | 0 | T. |
| Common White: | | | | |
| Honor | 6161 | ARG. | 0 | T. |

[a] Legend: A=Awnless; B=Bearded; W=White chaffed; R=Red chaffed; G=Glabrous, or smooth chaffed; V=Velvet chaffed.

[b] T=less than 0.5 per cent; 0=no disease; —=not tested at that place.

[c] Received by the Indiana Agricultural Experiment Station from Brunswick, Germany.

[d] Either a somewhat resistant strain or mixed somewhat with some similar resistant variety.

[e] A strain descended from a single plant selection. Other varieties of the Fulcaster group to which this strain is similar are generally immune.

The following varieties, representing 6 per cent of the entire series, showed infection percentages ranging from 1 per cent to 5 per cent, and may be classified, for the sake of convenience, as slightly susceptible: Kessinger, Selection No. 13631, Niagara, Selection from Indiana Swamp (C. I. No. 3334), Red Cross (C. I. No. 5318), Jones Fife, Brown Bearded,[5] Fultz, Illini Chief (Indiana Station), Pennsylvania Bluestem, Poole, and Fultz (C. I. No. 3598).

The Fultz wheats, noted above in the susceptible and slightly susceptible lists, are strains developed from single plant selections, one at the Kentucky Agricultural Experiment Station and the other two by the United States Department of Agriculture. The strain of Fultz, C. I. No. 5308, is not typical of this variety but is somewhat similar to Harvest Queen in appearance. Fultz, C. I. No. 1923, a variety developed by mass selection, showed only a trace of disease. Fultz also appears in the immune list, but apparently pure, being represented there by a number of strains which did not show infection.

The remaining 13 varieties listed in Table I, also representing 6 per cent of the entire series, developed the disease to an extent of less than 0.5 per cent, and these percentages, with one exception, occurred only with the series in Indiana. This slight infection possibly may at times be due to slight varietal admixtures present in the seed used. The varieties to which reference is made are: Budapest, Alabama, Currell, Enterprise, Fultz (C. I. No. 1923), Honor, Leap, Malakof, Mediterranean (C. I. No. 3332 and 3467), Selection No. 131156, and Stoner (Marvelous, C. I. No. 3605). Each plant of these varieties in the Indiana series was critically examined at the final note taking and there is no question that the one or two diseased plants recorded for each variety showed typical rosette. It can not be stated definitely as to whether or not the same varieties in the Illinois series possessed traces of the disease. At least no signs of the disease could be detected at first examination. On account of the extremely luxuriant growth of wheat plants in the Granite City district, it was very difficult to locate single diseased plants. In northern Indiana, on the other hand, the growth was very much less luxuriant and the presence of one or two diseased plants in a row was very noticeable.

In general, higher percentages of the disease were obtained in the experiments in Illinois than in Indiana. This is in accord with the previous results of McKinney[6] and probably is explained on the basis of more abundant soil infestation in the case of the Granite City soil as shown by the quantity of disease developing in the control variety. Although Illini Chief had a considerably higher percentage in Indiana than in Illinois, this is not surprising, since this variety has given the most inconsistent results of all the varieties tested during previous years. In 1920, Illini Chief (from the Alhambra [Ill.] Experiment Station) showed the disease in degrees ranging from 25 to 30 per cent; in 1921, both the Illinois Agricultural Experiment Station and C. I. No. 5406 strains of this variety had less than 1 per cent; in 1922, the Indiana strain of Illini Chief developed 16 per cent of rosette in both the Illinois and Indiana plats.

[5] A bearded wheat with red, glabrous chaff and soft, red kernels imported from Podolia, Russia, in 1910, by Office of Foreign Seed and Plant Introduction as S. P. I. No. 28588.

[6] McKinney, H. H. op. cit.

## VARIETIES RESISTANT TO ROSETTE

Varieties and strains resistant to the rosette disease are listed in Table II.

The number of varieties showing no infection by the rosette disease at either of the places where experiments were conducted is much larger than the number of those showing the disease, as given in Table I. Identification numbers, sources of seed, and descriptions of varieties, similar to those used in Table I are also included.

TABLE II.—*Varieties of winter wheat showing no infection by the rosette disease in experiments conducted in the crop year 1921–22, at Granite City, Ill., and Wanatah, Ind., arranged according to classes, with head characters for each.*

| Variety. | C. I. number or source. | Head characters.[a] |
|---|---|---|
| Hard Red Winter: | | |
| Alton (Ghirka Winter) | 1438 | AWG. |
| Beloglina | 2239 | BWG. |
| Do.[b] | Ind. Sta. | BWG. |
| Blackhull [c] | 6251 | BWG. |
| Kanred | 5146 | BWG. |
| Do | Kans. Sta. | BWG. |
| Do.[b] | Ind. Sta. | BWG. |
| Do.[b] | do. | BWG. |
| P 1066 [b] | do. | BWG. |
| P 1068 [b] | do. | BWG. |
| Preston [d] | 3081 | BWG. |
| Turkey | 6152 | BWG. |
| Minnesota [b] | Ind. Sta. | BWG. |
| Do. (Wis. Ped. No. 2) | Wis. Sta. | BWG. |
| Turkey— | | |
| Alberta Red [b] | Ind. Sta. | BWG. |
| Crimean | 5569 | BWG. |
| Malakof | 4898 | BWG. |
| Do.[b] | do. | BWG. |
| Theiss | 1561 | BWG. |
| Soft Red Winter: | | |
| Ahrens | 4848 | ARG. |
| Big Harvest Fultz [b] | Ind. Sta. | AWG. |
| Climax (Jones Climax) [b] | do. | AWG. |
| Currell | 2906 | ARG. |
| Do | 3326 | ARG. |
| Do | 4802 | ARG. |
| Evans | 2946 | AWG. |
| Do | 3079 | AWG. |
| Farmers Friend [b] | Ind. Sta. | BWG. |
| Forward [b] | do. | AWG. |
| Fulcaster (row 959 in 1918) | (e) | BWG. |
| Do | 4862 | BWG. |
| Do | 3407 | BWG. |
| Do | 3013 | BWG. |
| Fulcaster— | | |
| Blue Ridge [b] | Ind. Sta. | BWG. |
| Dietz | 1981 | BWG. |
| Do | 3387 | BWG. |
| Eversole | 3011 | BWG. |

[a] Legend: A=Awnless; B=Bearded; W=White chaffed; R=Red chaffed; G=Glabrous or "smooth" chaffed; V=Velvet chaffed.
[b] Tested at Wanatah, Ind., only.
[c] Usually with black stripes.
[d] A spring wheat, fall-sown here.
[e] From wheat breeding nursery of C. E. Leighty, Arlington Experiment Farm, Rosslyn, Va.

TABLE II.—*Varieties of winter wheat showing no infection by the rosette disease in experiments conducted in the crop year 1921–22, at Granite City, Ill., and Wanatah, Ind., arranged according to classes, with head characters for each*—Continued

| Variety | C. I. number of source. | Head characters. |
|---|---|---|
| Soft Red Winter—Continued | | |
| Fulcaster—Continued | | |
| Lancaster | 1945 | BWG. |
| Stoner (Marvelous) | 5619 | BWG. |
| Stoner | 2980 | BWG. |
| Fultz [b] | Ind. Sta | AWG. |
| Do | 3594 | AWG. |
| Do | 3598 | AWG. |
| Do | 3423 | AWG. |
| Do | 3349 | AWG. |
| Do | 3604 | AWG. |
| Fultz (Jersey Fultz) | 5360 | AWG. |
| Fultz (Kentucky pure-line selection) | 6942 | AWG. |
| Fultz Selection | 1923–6 | AWG. |
| Fultzo-Mediterranean | 5353 | AWG. |
| Gipsy | 3439 | BWG. |
| Do | 3440 | BWG. |
| Gipsy— | | |
| Reliable | 3508 | BWG. |
| Gladden | 5644 | BWG. |
| Do. [b] | Ind. Sta | BWG. |
| Goens— | | |
| Red Chaff [b] | do | BRG. |
| Golden Wave | 6684 | BRG. |
| Grandprize (St. Louis Grandprize) | 5627 | ARV. |
| Jones Fife | 5608 | AWV. |
| Jones Fife— | | |
| Super | 5544 | AWV. |
| Mammoth Red | 2008 | BWG. |
| Mealy | 3563 | AWV. |
| Do | 3565 | AWV. |
| Do | 5404 | AWV. |
| Mediterranean | 1395 | BRG. |
| Do | 2908 | BRG. |
| Do | 3467 | BRG. |
| Do | 3332 | BRG. |
| Michikoff [b] | Ind. Sta | AWG. |
| Odessa | 6151 | AWG. |
| Ontario (Ontario Wonder) | 3483 | AWG. |
| Padui | 6153 | AWG. |
| Palmer | 6685 | ARG. |
| Poole [b] | Ind. Sta | ARG. |
| Poole— | | |
| Harvest King | 5647 | ARG. |
| Hedge Prolific | 4859 | ARG. |
| Portage [b] | Ind. Sta | ARG. |
| Do | 5370 | ARG. |
| Prosperity (American Bronze) | 5638 | AWG. |
| Purdue No. 1 | 4871 | AWG. |
| Purplestraw | 1915 | AWG. |
| Red May | 5339 | ARG. |
| Red May— | | |
| Early Harvest | 4852 | ARG. |
| Early Ripe | 5319 | ARG. |
| Michigan Amber [b] | Ind. Sta | ARG. |
| Do | 4864 | ARG. |

[b] Tested at Wanatah, Ind., only.

TABLE II.—*Varieties of winter wheat showing no infection by the rosette disease in experiments conducted in the crop year 1921–22, at Granite City, Ill., and Wanatah, Ind., arranged according to classes, with head characters for each*—Continued

| Variety. | C. I. number or source. | Head characters. |
|---|---|---|
| Soft Red Winter—Continued | | |
| Red May—Continued | | |
| Michigan Wonder | 5321 | ARG. |
| Orange | 4868 | ARG. |
| Pride of Indiana | 3492 | ARG. |
| Red Cross | 3579 | ARG. |
| Red Rock [b] | Ind. Sta. | BRG. |
| Red Wave | 4872 | ARG. |
| Rudy | 3656 | BWG. |
| Do [b] | Ind. Sta. | BWG. |
| Russian Red— | | |
| Red Russian | 3497 | BRG. |
| Treadwell | 3527 | BWG. |
| Triplet | 5408 | AWV. |
| Triumph | 3134 | BRG. |
| Trumbull | 5657 | AWG. |
| Do [b] | Ind. Sta. | AWG. |
| Tule | 4140 | AWV. |
| Do | 3554 | AWV. |
| Wheedling | 4846 | ARG. |
| White Bearded | 3135 | BWG. |
| Winter Chief | 4878 | ARG. |
| Zimmerman [b] | Ind. Sta. | AWG. |
| White Club: | | |
| Hybrid 128 | 4512 | AWG. |
| Common White: | | |
| Bearded Winter Fife | 1942 | BWV. |
| Gold Coin | 5355 | ARG. |
| Gold Coin— | | |
| Junior No. 6 | Hickox-Rumsey Co. | ARG. |
| Jones Paris Prize | 3568 | ARG. |
| New Amber Longberry | 3361 | BRG. |
| Plant characters not recorded: | | |
| Akakawaka [b] | Ind. Sta. | |
| Burbank Wonder [b] | do. | |
| Diana [b] | do. | |
| Dirk [b] | do. | |
| Purdue Hybrid (Rows 5 and 8) [b] | do. | |
| Turkey x Bearded (Minnesota 47) [b] | do. | |
| Selections from hybrids and varieties: [f] | | |
| Crimean x Fultz, row 5 in 1919 | [e] | AWG. |
| Crimean x Fultz, rows 6 to 9 and 11 in 1919 | [e] | BWG. |
| Crimean x Poole, rows 27, 34 to 39, 41, 45, and 46 in 1919. | [e] | BWG. |
| Crimean x Poole, rows 28, 29, 33, 42, 44, and 47 in 1919. | [e] | AWG. |
| Crimean x Poole, rows 31, 32, and 48 in 1919 | [e] | BRG. |
| Crimean x Poole, row 43 in 1919 | [e] | ARG. |
| Crimean x Spelt, row 26 in 1919 | [e] | BWG. |
| Currell x Fultz, rows 12, 13, 19, and 22 in 1919 | [e] | AWG. |
| Currell x Fultz, rows 14 to 18, 21, 23 to 25 in 1919 | [e] | ARG. |
| Fultz x Poole, rows 81, 86 to 89 in 1919 | [e] | ARG. |
| Fultz x Poole, rows 82 to 85 in 1919 | [e] | AWG. |
| Genesee Giant x Mealy, row 51 in 1919 | [e] | ARG. |
| Genesee Giant x Mealy, row 53 in 1919 | [e] | BWV. |

[b] Tested at Wanatah, Ind., only.
[e] From wheat breeding nursery of C. E. Leighty, Arlington Experimental Farm, Rosslyn, Va.
[f] All wheats in this group have red kernels unless otherwise noted.

TABLE II.—*Varieties of winter wheat showing no infection by the rosette disease in experiments conducted in the crop year 1921–22, at Granite City, Ill., and Wanatah, Ind., arranged according to classes, with head characters for each*—Continued

| Variety. | C. I. number of source. | Head characters. |
|---|---|---|
| Selections from hybrids and varieties—Continued | | |
| Genesee Giant x Mealy, row 59 in 1919 | [c] | ARV. |
| Genesee Giant x Fultz, rows 62 and 66 in 1919 | [c] | BRG. |
| Genesee Giant x Fultz, rows 63 to 65, and 72 in 1919. | [c] | BWG. |
| Genesee Giant x Fultz, row 68 in 1919 | [c] | ARG. |
| Genesee Giant x Fultzo-Mediterranean, rows 74, 76, and 78 in 1919. | [c] | BWG. |
| Genesee Giant x Fultzo-Mediterranean, rows 77 and 79 in 1919. | [c] | ARG. |
| Genesee Giant x Fultzo-Mediterranean, row 93 in 1919. | [c] | AWG. |
| Pennsylvania 44 x Fulcaster [b] | Ind. Sta. | BWG. |
| Spelt x Turkey, row 92 in 1919 | [c] | AWG. |
| Turkey x Dale, row 91 in 1919 | [c] | BWG. |
| Turkish Amber x Dale, row 2 in 1919 | [c] | BRG. |
| Turkish Amber x Dale, row 4 in 1919 | [c] | BWG. |
| Selection, row 524 in 1921 | From 5661 [c] | AWG. |
| Selection | From 4131 [c] | AWG. |
| Selection, 13858 | From 1442 [c] | BWG. |
| Selection [g] (common) | From 1593 [c] | BRG. |
| Selection, row 393 in 1918 | From 3628 [c] | BWG. |
| Selection, 131058 | From commercial seed. [c] | AWG. |
| Selection, 131218 | do | BWV. |

[b] Tested at Wanatah, Ind., only.
[c] From wheat breeding nursery of C. E. Leighty, Arlington Experiment Farm, Rosslyn, Va.
[g] White kernels.

In addition to the resistant varieties listed in Table II, two others should be mentioned, namely, Shepherd and a resistant selection from Harvest Queen. In 1922, in connection with investigations on flag smut conducted by W. H. Tisdale, G. H. Dungan, and C. E. Leighty,[7] an increase plat of Shepherd (C. I. No. 6163) was grown on rosette-infested land near Granite City, Ill. In this plat no rosette developed during 1922, indicating that Shepherd is immune from the rosette disease. This is of especial importance, as this variety has been shown by Tisdale, Dungan, and Leighty to be immune from flag smut during the three years tested. This variety is awnless, with red glabrous chaff, and has soft red kernels. It yielded well near Granite City in 1922.

Shepherd originated from a head selection made in 1912 at Cornell University by one of the authors (Leighty) from plants grown from seed obtained from the Indiana Agricultural Experiment Station. It was grown in the crop year 1912–13 at Arlington Experiment Farm, near Rosslyn, Va., where it seemed promising and was increased.

A resistant selection of Harvest Queen (the so-called Salzer's Prizetaker) has been developed by H. H. McKinney. It was obtained by selecting, in 1919, a number of heads of this variety from plants that had developed normally on badly disease-infested land near Granite City. This strain

[7] TISDALE, W. H., DUNGAN, G. H., and LEIGHTY, C. E. FLAG SMUT OF WHEAT, WITH SPECIAL REFERENCE TO VARIETAL RESISTANCE. Ill. Agr. Exp. Sta. Bul. 242, p. 511–538, 3 fig. 1923. Literature cited, p. 538.
——— ——— ——— FLAG SMUT OF WHEAT. U. S. Dept. Agr. Circ. 273, 6 p., 2 pl. 1923.

apparently has all of the good qualities of the Harvest Queen variety, which has always been looked upon with favor by farmers, especially in the Granite City area. Harvest Queen is awnless, is a good yielder, stands the winter well, has a tall, strong straw, and produces a good, marketable quality of grain, of the soft red winter class. This resistant selection has shown 100 per cent freedom from the rosette disease when resown on badly infested soil in each of the three years since the original mass selection was made. Heads taken from this selection in 1922 are being grown in head rows in connection with flag smut experiments. It is hoped that a highly desirable strain, resistant to both diseases, may be obtained in this way.

In the list of varieties that have shown no infection are many of the important wheats of the United States. Five important classes, hard red spring, hard red winter, soft red winter, common white, and club, are represented. These five classes comprise more than 90 per cent of the wheat grown in the country, the two classes, hard red winter and soft red winter, being of nearly equal importance and making up more than 60 per cent of the annual acreage of the wheat crop. The resistant varieties listed in Table II are those used for sowing about one-eighth of the hard red spring wheat acreage, nearly all of the hard red winter wheat acreage, by far the larger part of the soft red winter wheat acreage, about a third of the common white wheat acreage, and about one-fifth of the club wheat acreage.

The only widely grown variety that has been found to be highly susceptible is the Harvest Queen. Several other important wheats have shown a slight percentage or a trace of infection (Table I), but in some cases the strain showing infection represents only a selection developed in connection with wheat breeding, and not the commercial variety.

## CONTROL OF ROSETTE

The rosette disease has been controlled in the localities where it has been found by the use of varieties that are immune from the disease. In the Illinois area near Granite City, the Harvest Queen variety (known locally as Salzer's Prizetaker) was the principal one being grown when the disease was discovered in 1919. This variety is very susceptible to the disease. Conditions, therefore, were very favorable for the appearance of the disease, and it was widely distributed in this area in the year of discovery. Losses were heavy that year in the fields most severely infected. In later years Red Wave, which appears among the immune varieties, was largely substituted for the Harvest Queen variety. Fultz, many strains of which are immune or highly resistant, also was used to some extent. In addition to these soft red winter varieties, a number of hard red winter wheats of the Turkey type, such as Illinois 10–110 and Kanred, have been sown. These hard wheats also are immune.

On account of the large number of varieties immune to the rosette disease it is not difficult to control it in farm practice. However, the presence of flag smut in southern Illinois in the same locality with rosette is a complicating factor. As shown by Tisdale, Dungan, and Leighty [8] there are several varieties that are immune or highly resistant to flag smut, but not so many as are resistant to rosette. The varieties resistant to both diseases are still fewer in number.

[8] TISDALE, W. H., DUNGAN, G. H., and LEIGHTY, C. E. OP CIT.

The soft red varieties, Red Wave and Fultz, now being grown in the Granite City area, while immune to rosette disease, are somewhat susceptible to flag smut. The hard red varieties, Illinois 10–110, Kanred, etc., are practically immune from both diseases, but are not entirely satisfactory from the farmer's standpoint in the southern Illinois area. Conditions of climate and soil are not suitable for this type of wheat.

Several adapted varieties, however, are available which possess high resistance to both diseases. These are being introduced into the Illinois area where both wheat rosette and flag smut occur. A few strains, developed in connection with wheat breeding operations, have not become infected by either disease, and these are being increased for further testing and distribution.

# TWO DISEASES OF UDO (ARALIA CORDATA THUNB.)[1]

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In the summer of 1920 the writer's attention was called to two diseases of udo which were apparently of different origin. A specimen of one, a rootrot, was sent to the Office of Cotton, Truck and Forage Crop Disease Investigations, United States Department of Agriculture, by Dr. David Fairchild. The other disease was killing the udo plants in the garden of Dr. W. A. Orton at Takoma Park, D. C. The writer undertook to determine the cause of these diseases, and the purpose of this paper is to record his findings.

## HOST

The udo is a species of Aralia, namely, *Aralia cordata* Thunb., introduced into the United States in 1903 by Lathrop and Fairchild from Japan, where it is grown extensively for food. It is a hardy perennial plant which produces strong young shoots each spring. These are blanched and used as a vegetable like asparagus. The plants are usually grown from seed, although they may be propagated by cuttings. They sometimes grow to be from 4 to 6 feet high the first season. After the first frost the tops die down and the plant remains dormant during the winter, coming up again the following spring much the same as do asparagus and rhubarb. The general character of this plant is apparent from the illustrations. For further details regarding its history, habits of growth, and methods of cultivation, the reader is referred to a paper by Fairchild (*5*).[2]

## ROOTROT

The first specimen of this disease seen by the writer came from Dr. Fairchild's farm near Chevy Chase, Md. Other specimens were received later from the same source, as well as from a planting at Bell, Md. What appears to be the same disease was reported by Fairchild (*5*) to have been present in his first udo planting, regarding which he states, "The writer discovered a soft rot of the roots which killed a number of apparently vigorous plants on the farm of the Department of Agriculture at Arlington, Va., the cause of which proved to be a sclerotium-producing fungus, the mature form of which has not yet been observed." No experimental data are given to show that the sclerotium-producing fungus mentioned was the cause of the disease, and Dr. Fairchild requested further information regarding the cause of this trouble.

Diseases resulting from sclerotium-producing fungi seem to have attained unusual prominence during the past few years. A disease of lettuce known as "drop" caused by *Sclerotinia libertiana* Fcl. has long been known and studied. More recently a disease of sunflower (*Helianthus annuus* L.) has been described by Bisby (*1*), who did not determine the causal organism, but states that it is very similar to *Sclerotinia liber-*

[1] Accepted for publication Aug. 11, 1923.
[2] Reference is made by number (italic) to "Literature cited," p. 278.

*tiana*. Lawrence (*8*) described a new species of sclerotium-producing fungus, which he named *Sclerotinia perplexa* nov. sp. This fungus attacks sunflower, as well as several other plants, causing a disease very similar to the one described by Bisby. It differs from *Sclerotinia libertiana* in that it has a conidial stage. A similar disease of sunflower is also described by Morris and Swingle (*9*), who state that the causal fungus resembles *Sclerotinia libertiana* very closely. Jagger (*6*) has described a new species of Sclerotinia on lettuce, celery, and other crops, similar to *S. libertiana*, except that the sclerotia are much smaller. Likewise, Dana (*4*) has reported two new species of Sclerotinia, namely, *S. gregaria* and *S. demissa*, which attack *Amelanchier cusickii* and *Prunus demissa* respectively. These two fungi also have a conidial stage.

The disease of udo under discussion has been called "rootrot." The stem of the host is also attacked, but less vigorously than the roots. The writer has not had an opportunity to observe this disease under field conditions, except in the case of a few plants. In these cases the disease did not become evident until the plants were about three-fourths grown. One large plant, which was observed on October 24, 1920, had 10 to 15 stems. The leaves were dying from the base of the plant towards the top, being at this time dead about two-thirds of the way up. Under the conditions to which this plant was subjected the disease seemed to work very slowly, requiring practically a whole season to kill the plant completely.

The leaves, as well as the lower part of the stem of the infected plants, died and turned brown, and the roots decayed. A number of large, black, irregular-shaped sclerotia were usually present on or in the dead and dying stems and roots (Pl. 1, D). When small plants growing in the greenhouse became infected the leaves wilted, the petioles lost their turgidity and broke down, and the stems soon became so completely decayed that the whole plants collapsed (Pl. 2, B and C). In case of small plants the petioles which came from beneath the soil rotted (Pl. 1, B and C), and under humid conditions a mass of white mycelium grew over their surfaces. The infected area of the stem was brownish in color and had the appearance of being water-soaked or scalded. The small infected roots soon became a soft watery mass of more or less isolated cells interwoven with mycelium and later interspersed with sclerotia.

## THE CAUSAL ORGANISM

Numerous isolations have been made by planting bits of diseased tissue from the interior of the root, as well as disinfected sclerotia, on sterile culture media. In all cases the same fungus was obtained. After growing this fungus on different culture media and using it in making numerous inoculations, through a period of two years, the writer is forced to conclude, as did Bisby and Morris and Swingle in case of the fungus from sunflower, that the fungus which causes the rootrot of udo is very similar to, if not identical with, *Sclerotinia libertiana*. The sclerotia vary greatly in size, apparently depending upon the nature of the substratum and upon environmental conditions, such as temperature and humidity. These, however, do not vary sufficiently to prevent the fungus from being classed as *S. libertiana*, since it has been shown by Stevens and Hall (*11*) that the sclerotia of this fungus are also variable in size. No conidia other than the microconidia have been found, either on the host or in culture. The microconidia are similar in size and shape to those of *S. libertiana*.

The two fungi also have the same appearance in culture and have the same maximum, optimum (22–25° C.), and minimum temperatures. Besides this, when udo was inoculated with an authentic culture of *Sclerotinia libertiana*, a disease was produced which was similar in every respect to that caused by the Sclerotinia from udo.

Attempts to develop the apothecia from the sclerotia have been made several times during the past two years. Sclerotia of different sizes which had developed in the host or in culture were buried in or placed upon sand in small flasks, tumblers and crystallizing dishes. They were then kept moist and held in diffused light at room temperatures (15 to 25° C.) for several weeks. Similar trials were made at different times of the year in order to subject the sclerotia to different conditions of temperature and light. *Sclerotinia libertiana* sclerotia develop apothecia very abundantly in Florida, where they seem to find conditions very favorable during the autumn and winter months. A small quantity of the sclerotia taken from udo were therefore sent to Dr. I. C. Jagger, at Sanford, Fla., who placed them under what seemed to be ideal conditions for the development of apothecia by sclerotia of *Sclerotinia libertiana*. Here sclerotia of the latter held under the same conditions as controls developed apothecia, while the sclerotia from udo did not. At Berkeley, Calif., in the winter of 1922–23, sclerotia, produced by an authentic strain of *S. libertiana*, isolated by Jagger from an apothecium grown on Irish potato agar, together with sclerotia from parallel cultures of the fungus from udo, were placed in moist sand and on filter paper in tumblers and held for several months at room temperature (15 to 25° C.) in diffused light. In about a month the sclerotia of *S. libertiana* produced apothecia in abundance, both in the sand and on moistened filter paper, while those of the Sclerotinia from udo failed to produce apothecia, even after several months. Since the writer has been unable to obtain the ascigerous stage, the fungus from udo could not be definitely determined. It is safe to say, however, that it is very similar to *Sclerotinia libertiana* and is probably a strain of this fungus.

## PATHOGENICITY

As stated above, the fungus has been isolated a number of times from the diseased host tissue. It has also been obtained by disinfecting the sclerotia formed in or on the diseased parts of the host with equal parts of 95 per cent alcohol and mercuric chlorid solution (1 to 1,000), washing in sterile distilled water, and then planting them on agar. The fungus thus obtained has on several occasions been inserted through wounds in the host and infection obtained. In these experiments the soil was first removed from the base of the plant, a wound was made with a sterile scalpel in the root or underground part of the stem, and mycelium from pure culture was inserted in the wound, which was then closed as carefully as possible and the soil replaced about the plant. In some of the experiments hyphae were laid against the uninjured root and covered with moist soil. Control plants were treated in the same manner in each case, except that no inoculum was used. Plants of different ages were used in these experiments, some being only a few weeks' old and others more than a year old. Isolations were made and the organism recovered in practically every case. The fungus isolated was again inserted in the host, infection obtained, and the fungus reisolated so that Koch's rules of proof were fully carried out. For details of some of the experiments see Table I.

TABLE I.—*Nature and results of experiments conducted to prove the pathogenicity of the fungus from udo*

| Date inoculations were made. | Number of plants inoculated. | Number of controls. | Where growing. | Method of inoculation. | Number of inoculated plants infected. | Number of controls infected. |
|---|---|---|---|---|---|---|
| Mar. 30, 1921... | 5 | 5 | Greenhouse. | Inserted hyphae in wounds. | 3 | 0 |
| May 13, 1921... | 15 | 10 | ...do... | .....do..... | 4 | 0 |
| Do..... | 10 | 10 | ...do... | Placed hyphae against root; no wound. | None. | 0 |
| Apr. 11, 1922... | 10 | 10 | ...do... | Inserted hyphae in wounds. | 10 | 0 |
| May 17, 1922.... | 20 | 10 | ...do... | .....do..... | 2 | 0 |
| Do..... | 5 | 10 | ...do... | Placed hyphae against root; no wounds. | None. | 0 |
| May 24, 1922.... | 3 | 3 | Field.. | Inserted hyphae in wounds. | 1 | 0 |

An examination of Table I shows that only in the experiment begun on April 11, 1922, was 100 per cent infection obtained. In another case, begun May 17, 1922, only 2 plants out of 20 became infected. The small percentage of infection in this case is attributed to too high temperature, since a correlation was always apparent between the temperature and the number of plants infected. In no case was infection obtained in unwounded plants. Wounds through which the fungus can enter seem to be necessary. Too small a number of tests were made, however, to establish this point conclusively. The largest number of plants became infected when they were growing vigorously and the temperature was fairly low, as was the case in the experiment conducted in April, 1922. Infection became evident in the inoculated plants in from three days to two weeks. The softening of the root and the discoloration of the stem were the first symptoms. These were followed by wilting, yellowing, and finally a browning of the leaves, as previously described. In one experiment the fungus had in 6 days penetrated the tissues of the host for a distance of 2 to 3 inches above and below the point of inoculation. The plants used in this case were about a year old; they were growing in pots and had been placed out of doors during the winter months. In the early spring they were brought into the greenhouse, where they began to make a vigorous growth almost at once; so that at the time of inoculation they were about 2 feet high. The writer had little success in growing these plants unless each winter they had been subjected for a time to a freezing temperature.

The infected stems lost their dark green color, becoming grayish and water soaked, gradually changing to yellow, and finally to brown. The external tissues of the infected stem usually remained firm to the touch, owing to the presence of the large quantity of vascular tissue located just beneath the epidermis, but the stem has a large pith, which was soon softened. The cells of the pith were plasmolyzed and fell apart, showing that the middle lamellae of the cells had been dissolved. The decayed tissue was filled with large, densely granular hyphae, which appeared to find here a very favorable medium for growth. The breaking down of the middle lamellae and consequent softening of the tissue

took place considerably in advance of the hyphae, showing that this was due to an enzym, no doubt a pectinase. The browning of the vascular bundles before the appearance of the hyphae was especially noticeable, although their cells did not seem to lose coherence, at least to the same degree as did the pith cells. This fact seems to indicate the presence of some toxic substance.

In the infected roots practically all of the tissues appeared to lose their coherence to a greater or less degree; the epidermis, however, remained intact. A large quantity of sap could be squeezed from the decayed root. Little if any change in the color of the root took place, even when it was entirely decayed. The decayed tissues of the root, as well as those of the stem, were filled with mycelium. Sclerotia of varying sizes and shapes, at first white, but gradually turning black, were found throughout the diseased root and stem, as well as on their surfaces. The decayed tissues eventually disintegrated, leaving the sclerotia in the soil.

Probably insects and rodents are the chief agents in distributing this fungus, although it is possible that the fungus growing saprophytically in the soil may gain entrance to the roots through root hairs, dead rootlets, or wounds made during cultivation or cutting.

## CONTROL

The control of diseases caused by species of Sclerotinia has proved to be difficult, especially under field conditions. Where the crop is grown in the greenhouse or can be subjected to cold-storage conditions the problem of disease control is greatly simplified. However, the udo is strictly a field crop and, being a perennial, is grown continuously in the same field for several years. The practicability of crop rotation as a control measure is therefore not great. It is quite obvious, however, that certain useful precautions can be taken. Should the causal organism prove to be *Sclerotinia libertiana*, as the writer believes, its distribution in this country is very general, and its available hosts many and various. Obviously, therefore, it is difficult to obtain land free from the fungus on which to start a planting. For growing udo care should be exercised to select land on which no plants known to be susceptible, such as lettuce, celery, cabbage, carrots, and still others have been grown for a number of years. It is a wise precaution to have the udo planting some distance away from trucking centers, where so many susceptible hosts are grown. The plants should preferably be grown from seed, thus eliminating the danger of carrying the disease to the new planting on old roots. The disease may be brought to the field in particles of soil on cultivators or other tools, or by man or animals. Since a majority of infections probably occur through wounds, precautions should be taken to avoid wounding the plants during cultivation, by cutting young shoots or otherwise. Plants which have become infected should be taken up at once, all diseased parts should be eliminated, and any soil which may contain sclerotia or mycelium should be removed. If the disease is detected in its early stage and the plant taken up at once before sclerotia are formed, there will be less danger of scattering the fungus about the field. By observing these precautions the grower should be able to keep the disease fairly well under control for some time. When once the land becomes infested the growing of udo upon it should be discontinued, at least for several years.

Nothing is known regarding susceptible or resistant varieties.

60377—23——3

## WILT

While the writer was studying the rootrot Dr. W. A. Orton called his attention to another disease attacking udo. The leaves were turning yellow, then brown, and drying up. The petioles also died, and usually clung to the stalks for some time. Plate 3 illustrates at the right the naturally infected plants in Doctor Orton's garden, and at the left those slightly or not at all infected. Plate 4, C, shows a healthy plant in blossom, used as a control; B, a diseased plant; A, a plant in an advanced stage of the disease. The plants shown in A and B were inoculated four months before the photographs were made.

## ETIOLOGY

Numerous isolations have been made from diseased plants, and a pure culture of *Verticillium alboatrum* R. and B. was obtained in a large percentage of cases. So far as the writer has been able to ascertain, this fungus has not been reported heretofore as causing a disease of this host, although it is known to attack a considerable number of other plants (*10*, *7*, *3*, *2*).

Verticillium was isolated from the diseased tissue of udo, and inoculation experiments were tried to determine its pathogenicity. Udo plants grown from seed in the greenhouse were inoculated by inserting hyphae and spores from a pure culture into the healthy plant through wounds made with a sterile scalpel. The soil was removed from the base of the plant to be inoculated, so that the underground portion of the stem and a part of the root were exposed; the inoculum was inserted and the soil was replaced. Plants similarly treated, except that no inoculum was used, served as controls. In one experiment large udo plants growing out of doors were inoculated in the same manner as described above.

On May 23, 1921, 10 plants growing in the greenhouse were inoculated and 5 others were prepared and held as controls. On June 18 all of the inoculated plants showed signs of the disease. The disease developed slowly, and by October two of the plants were entirely dead, while the remainder were greatly stunted, had some dead leaves, and were very low in vigor. Plate 4 shows two of the plants as they appeared in September. The fungus was recovered from about 50 per cent of the diseased plants. In most of the other cases the plantings remained sterile, but bacteria grew from a few of them.

A second attempt to produce infection in udo was made on March 18, 1922, when 10 plants were inoculated and 5 held as controls. All were about a year old, and had been subjected to freezing temperatures through the winter. When brought into the greenhouse they grew rapidly; by the time they were inoculated they were about 6 inches high. On April 5 the lower leaves of six of the inoculated plants began to turn yellow and die, and by June 23 most of them were nearly dead. *Verticillium alboatrum* was recovered from four of them. The controls remained healthy.

To test the ability of this fungus to cause infection under field conditions, three large udo plants growing in the field were inoculated in the usual manner, and three held as controls. The six plants were nearly 2 years old, having been started and grown for one season in the greenhouse before being removed to the field; they were about 4 feet high, and the stalks an inch in diameter. In three weeks the three

inoculated plants showed the early symptoms of the disease, and after a time more leaves became yellow. None of the controls or other plants growing near showed any dying or yellowing of the foliage.

This disease works slowly; the tops die gradually, and by the end of the season some of the plants may be dead, while others are living, though stunted and low in vigor. The living plants may make some growth the following year, and the disease may require two years or even longer to kill a plant completely.

The browning of the vascular system is apparent in these diseased plants—a characteristic of vascular diseases of other plants. The mycelium was found extending down to the tips of the roots, as well as up into the stem. It was isolated from the petiole of a leaf about 3 feet from the ground.

In order to learn whether or not this strain of *Verticillium alboatrum* causing wilt of udo would cause wilt of eggplant, the following experiment was performed. Fifteen eggplants were inoculated with the Verticillium from udo by the method described above, and 15 others were inoculated with a strain of the same fungus isolated from a wilted eggplant. Thirty plants of the same lot were held as controls. In 15 days unmistakable symptoms of the disease were present in some of each set of inoculated plants. Three days later an examination showed that 10 of the plants inoculated with the fungus from eggplant were dying, one being already practically dead, and 6 plants inoculated with the fungus from udo were diseased. The remaining plants showed no signs of the disease, nor did any of the controls. This experiment was repeated later, 10 plants being inoculated with each fungus. All of the plants inoculated with the fungus from eggplant and 7 inoculated with that from udo became infected. Evidently these two fungi were identical, not only morphologically, but parasitically. It is of interest to know that these fungi were isolated from naturally infected eggplant and udo growing in the same garden. The udo had been planted on soil which had previously grown wilted eggplants. Undoubtedly the strain of Verticillium which causes wilt of eggplant also causes the same disease of udo. Carpenter (3) has shown that *Verticillium alboatrum* isolated from okra, snapdragon, eggplant, and Irish potato will infect okra, and that the same fungus from eggplant, okra, and snapdragon will infect eggplant. It would seem, then, that *Verticillium alboatrum*, regardless of its source, is capable of attacking a number of plants in which it produces a characteristic wilt disease.

## CONTROL

Only sanitary measures can be suggested for the control of this disease. These may be briefly stated. Do not sow udo on land on which any plants affected with Verticillium wilt have been grown. It is not known whether or not this disease can be spread by means of infected seed, but it seems advisable to avoid such a possibility. If the disease appears the affected plants should be removed, great care being exercised not to spread the fungus about the field. Cuttings for propagation should never be made from diseased plants. When so many of the plants become diseased that the planting becomes unprofitable it should be abandoned and the plants destroyed. The new planting should be made as far away fom the old one as possible.

There are indications that the wilt is less destructive on a heavy soil than on a lighter, sandy loam.

SUMMARY

Two diseases of udo are described. The one is a rootrot caused by a fungus shown to be very similar to, if not identical with, *Sclerotinia libertiana*. The other is a wilt disease caused by *Verticillium alboatrum*.

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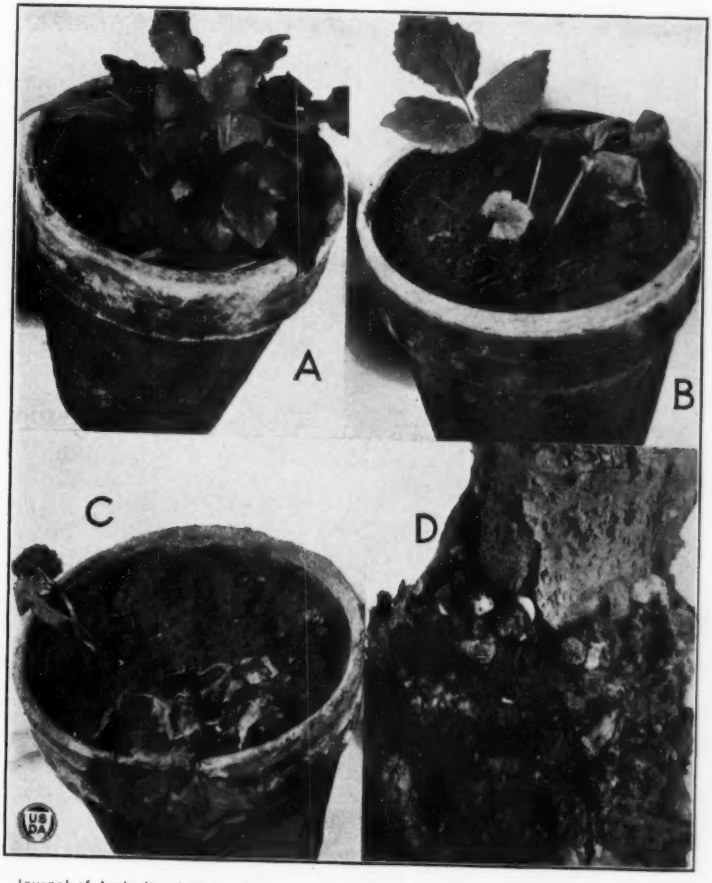
## PLATE 1

A.—Healthy udo plant used as control, of the same age as those shown in B and C

B, C.—Udo plants 5 days after being inoculated with the Sclerotinia from decayed udo roots. The roots, as well as the petioles, have decayed.

D.—Root of mature plant infected with Sclerotinia, showing the sclerotia present on its exterior, near the surface of the soil.

PLATE I



A
B
C

## PLATE 2

A.—Healthy udo plant used as control.

B, C.—Two udo plants, of the same age as the control, inoculated with the fungus from decayed udo root. The roots of these plants were almost entirely decayed and would no longer support the plants in an erect position. The bases of the stems were also decayed, and the leaves and petioles were losing their turgidity.

PLATE 3

A.—Section of udo planting in Doctor Orton's garden, showing at the right the diseased plants, and at the left those little or not at all affected.

C
B
A

## PLATE 4

A.—Udo plant almost entirely dead, owing to the ravages of the Verticillium with which it was inoculated 4 months before the photograph was made. The base of the stem still shows some signs of life.

B.—Same as A, except that the plant has been more resistant to the fungus.

C.—Control plant, given in every way the same treatment as the plants shown in A and B, except that no inoculum was inserted in the wound.

60377—23——4